U.S. DEPARTMENT OF COMMERCE
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PB-291 940

Lower Meramec River Basin Wastewater Treatment Facilities St. Louis, Missouri. Volume II

(U.S.) Environmental Protection Agency, Kansas City, MO

Dec 78

EPA-907/9-78-004

EPA-7-MO-ST. LOUIS-
ST. LOUIS COUNTY-
WWTP-78

PB 291940

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

LOWER MERAMEC BASIN

Volume II

MSD

Metropolitan St. Louis Sewer District
St. Louis, Missouri

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NATIONAL TECHNICAL
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SPRINGFIELD, VA. 22161

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Region VII - Kansas City, Missouri

285

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-907/9-78-004

2.

3. RECIPIENT'S ACCESSION NO.
PB291940

4. TITLE AND SUBTITLE
Draft Environmental Impact Statement
Lower Meramec River Basin Wastewater Treatment
Facilities, St. Louis, Missouri

5. REPORT DATE
December 1978

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Region VII

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Sames as Box 12

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS
U.S. Environmental Protection Agency
1735 Baltimore
Kansas City, Missouri 64108

13. TYPE OF REPORT AND PERIOD COVERED
Draft

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Metropolitan St. Louis Sewer District (MSD) has applied to the U.S. Environmental Protection Agency (EPA) for funding under Section 201 of the Federal Water Pollution Control Act as amended (P.L. 92-500) for construction of wastewater treatment facilities in the Lower Meramec River Basin. In consideration of this application and pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969 (P.L. 91-190), EPA has prepared an environmental impact statement (EIS) on the proposed plan and its alternatives. The proposed plan is a regional treatment system consisting of a single treatment plant near the confluence of the Meramec and Mississippi Rivers with secondary-level discharge to the Mississippi, and a deep-rock tunnel trunk line. Alternatives are: No action; and a sub-regional system with nine treatment plants and tertiary-level discharge to the Meramec. The study area includes both the St. Louis and Jefferson County portions of the Meramec River Basin and its watershed areas from Ellisville, Missouri to the Mississippi River.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT
Release unlimited. Copies are available from sponsoring agency at no charge until supplies are depleted.

19. SECURITY CLASS *(This Report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES
285

22. PRICE
PC A13/MF A01

EPA Form 2220-1 (9-73)

CHAPTER 5

ENVIRONMENTAL IMPACTS OF THE VIABLE PROJECT ALTERNATIVES

This section compares the environmental impacts of the project alternatives remaining after the screening process carried out in Chapter 4. These alternatives are:

1) No action

2) A subregional wastewater system with nine plants located near the mouths of the Keifer, Williams, Fishpot-Grand Glaize, Mattese, Fenton-Yarnell, Pomme, and Sugar Creeks and in drainages designated Meramec Subareas III and VI. Under this plan, tertiary treatment would be carried out with discharge to the Meramec. Sludge disposal would be by on-site lagooning.

3) A regional wastewater system with a single regional plant near the mouth of the Meramec which would treat wastewaters to a secondary level with discharge to the Mississippi. Sludge disposal would be by on-site lagooning. Two alternate conveyance systems will be evaluated under this plan:

    a) Trunk line by open-cut construction - This alternative involves the construction of approximately 20 miles of trunk line by surface excavation/installation, approximately 5.3 miles of additional collectors, and 14 pump stations.

    b) Trunk line by tunnel construction - This alternative involves the construction of approximately 16.7 miles of trunk line by deep-rock tunneling and approximately 7.6 miles of additional collectors.

This chapter will discuss and compare both the primary and secondary impacts of construction and operation of these alternate plans on the natural and man-made environments of the project area.

NOISE IMPACTS

Primary Impacts

Construction - The most significant noise impacts associated with any of the "build" alternatives will occur during construction. While construction activities are often regarded as "short-term", the duration of activities for a project of this type may extend for many years and, therefore, significantly affect both development patterns and the quality of life in the project area. The following paragraphs detail the noise impacts of each of the alternative plans.

No action: Under this alternative, the acoustic environment of the project area should remain similar to that under existing conditions, except where increased vehicular traffic levels on highways traversing the area occur. Based on the types of land use characteristic of the project area, the existing acoustic environment has expected ambient L_{50} (exceeded 50 percent of the time) levels of 45 to 55 dBA in undeveloped areas, and 70 dBA and above in localized areas proximate to high-volume highways and certain industries.

Subregional Plan: Major construction would be necessary to build the nine treatment plants and the collector systems. Based on indices obtained from the USEPA's "Noise from Construction Equipment and Operations, Building Equipment and Home Appliances" (099) for public works equipment, noise levels 50 feet from equipment performing the types of operations necessary for this construction would be as shown in Table 46.

As shown in Table 46, noise from construction activities could have significant adverse effects on nearby sensitive receptors such as residences or parks, depending on the relative serenity of these receptors. In a realistic context, however, it must be recognized that construction activities will not take place during the most sensitive night time periods and that most activities will occur in areas separated by distances of 200 feet or more from existing sensitive areas. At 200 feet, the levels shown in Table 46 would be lowered by about 12 dBA. In developed areas, such as parts of the Glaize, Fishpot, and Meramec Sub-area VI subbasins, however, much of the construction activity (especially the collector system) will take place near sensitive receptors and will have significant (i.e., elevating ambient levels by >9dBA) adverse effects on land uses in these areas, unless stringent abatement strategies are implemented.

TABLE 46

ANTICIPATED NOISE LEVELS
SUBREGIONAL PLAN

Activity	dBA With No Abatement	dBA With All Equipment Quieted by 10 dBA
Ground Clearing	100	84
Excavation	105	92
Foundation	108	90
Erection	88	77
Finishing	104	89

Under the subregional plan, these noise impacts would occur in the proximity of the nine treatment plants and the approximately 5.5 miles of collectors. Four of these plants and approximately 2.5 miles of collectors would be located close enough to sensitive receptors to create problems.

Regional Plan - Open-Cut Construction of Trunk: Significant noise-related difference between this plan and the subregional plan are as follows:

1) A single treatment plant will be located near the mouth of the Meramec near industrial uses instead of the nine plants proposed for the subregional plan.

2) A main trunk sewer will extend from near the mouth of Keifer Creek to the proposed regional plant near the mouth of the Meramec. This trunk sewer would, basically, follow the course of the Meramec River. It would involve open-cut excavation through approximately 20 miles of bottomland with approximately 5.3 miles of collectors required. Twelve river crossings would be required for the trunks and collector routes proposed.

3) Fourteen pump stations will be constructed along the route to transfer flow over high points along the trunk.

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Assuming the same levels of noise will be created by construction activities for both the subregional and regional plans, noise impacts under this plan may be compared to those under the subregional plan as follows:

1) Noise impacts caused by construction of the fourteen pump stations, the collector system, and the single regional plant would be roughly the same as those impacts caused by construction of the nine plants and collector system proposed under the subregional plan.

2) Noise impacts resulting from construction of the trunk sewer would be geographically widespread, would affect many types of land use, would occur over extended periods of time, and would involve ground clearing and excavation, which are two of the louder construction activities. Extensive dewatering would be required during this construction, which means that pumping equipment would often have to be operated at the same time as excavating and hauling equipment, thus further elevating noise levels.

Regional Plan - Tunnel Construction of Trunk: The collector system constructed under this plan would be similar to the system constructed under the subregional and the other regional plan. However, this collector system would involve approximately 7.5 miles of construction (as opposed to 5.5 miles and 5.3 miles, under the subregional and other regional plans, respectively) due to the alignment of the tunnel. A single treatment plant would be constructed in the same relatively non-sensitive area described above. No pump stations would be required,

Construction required for this alternative which differs from other alternatives is as follows:

1) Construction of a trunk sewer by deep-rock tunneling

2) Construction of approximately 30 construction shafts for access for tunnel construction and removal of excavated material

3) Construction of drop shafts connecting watershed collectors to the main trunk tunnel

Construction of the trunk tunnel would be subterranean (at depths of 100 feet or more). Noise from the excavation will most likely be nearly imperceptible at the surface. If tunnel ventilation is accomplished by surface exhaust fans, resulting noise levels would be in the order of 75 dBA at 50 feet (100).

5<

The building of a construction shaft can be divided into three basic operations: excavation from surface to bedrock; blasting of rock to desired depth; and, horizontal excavation by "mole". The first operation uses conventional excavation equipment and should have impacts as discussed above (i.e., 92 to 105 dBA at 50 feet) which will last two to four months per shaft. The second operation, blasting, will be subterranean and should not have a great surface impact. Noise from the third operation, excavation by mole, should not be perceptible at the surface.

Construction of drop shafts requires surface excavation much like that required for construction shafts, followed by drilling to the already excavated tunnel. Construction at these sites would, therefore, have impacts similar to other surface construction activities during the first few weeks of construction, followed by a more muffled underground drilling and muck-removal stage lasting a few months. The major noise impacts of drop-shaft construction are, therefore, short-term.

The construction noise caused by each of the four alternate plans may be compared as follows:

1) No action - No additional noise.

2) Subregional plan - Construction noise impacts would be in the vicinity of the collector systems and the nine regional plants, some of which are located near sensitive receptors. The general order of magnitude of the noise would be 77 to 108 dBA at 50 feet.

3) Regional plan - open-cut trunk line - Construction impacts of the same general magnitude as those caused by the subregional plan would be near the collector system, pump stations, along the entire 20-mile trunk route, and near the single regional plant.

4) Regional plan - trunk tunnel line - This alternative would have nearly identical construction impacts near the collector system and the single regional plant. There would be short-term construction impacts near the 15 or so drop shafts and longer-term impacts near the 30 construction sites.

Operation - At this stage in the planning process, detailed site plans of the alternate treatment plants and pump stations have not been prepared. The number of possible variations in site geometry, architecture, location of impulse noise sources, and other factors makes precise prediction of operational noise impacts nearly impossible (101). However, the following generalized set of acoustical assumptions is probably valid for the project area, for the purpose of comparison.

1) Sound levels will be in the general range of about 70 dBA at the periphery of a given plant or pump station

2) Plant sites will produce noise in the manner of hemispherical point sources with distance reductions of about 6 dBA, when doubling distances, or 20 dBA, when increasing the distance by ten times

3) The average existing L_{50} (exceeded 50 percent of the time) levels for the project area will be about 50 dBA for relatively undeveloped areas and about 55 dBA in more highly developed areas

On the basis of these assumptions, the impacts a given facility's operation will have on its surrounding environment may be as shown in Table 47.

As shown in Table 47, the effects of operational noise on receptors located directly adjacent to or within 100 feet of facilities would be significant. However, even if levels of noise produced were assumed to be as high as 80 dBA, areas 500 feet or more from a site would receive little or no noise from facilities.

TABLE 47

ANTICIPATED NOISE LEVELS

Distance From Plant	Noise Level Attributable (dBA)	Ambient L_{50} (dBA)	Increase in Noise (dBA)	Noise Impacts
Periphery	70	50-55	20-15	Great
50 feet	65	50-55	15-10	Great
100 feet	59	50-55	9-4	Great - Significant
200 feet	53	50-55	3-0	Minor - None
500 feet	45	50-55	0-0	None

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Based on the above discussion, operational noise impacts from the three action alternatives may be compared as follows:

1) Subregional plan - There will be adverse noise impacts within 100 to 200 feet of the nine plants. There will be intermittent impacts over a wider range. Most plants will be located away from sensitive receptors. In some cases, however, this would not be possible.

2) Regional plan - open-cut trunk - There will be adverse noise impacts within 100 to 200 feet of the single plant and of the 14 pump stations. Intermittent noise impacts will be wider ranging. Some of the pump stations will be located near sensitive receptors.

3) Regional plan - tunnel trunk - Adverse noise impacts will be within 100 to 200 feet of the single plant, with wide-ranging intermittent impacts. Again, the plant would be located away from sensitive receptors.

Secondary Impacts

Secondary noise impacts associated with all three of the "action" alternatives will be related to the increased development which the project would accommodate. Although it is impossible to accurately predict what these levels will be, a reasonable indication can be obtained by comparing the average sound level for a quiet suburban area, 50 dBA, with average sound levels under more highly developed suburban conditions, 55 dBA, or urban conditions, 60 dBA (124), which could be accommodated by the project.

AIR QUALITY IMPACTS

Primary Impacts

No directly related primary impacts on air quality are anticipated with the no action alternative. Primary impacts on air quality resulting from either the regional or subregional alternatives will be limited to temporary increases in suspended particulate concentrations in the vicinity of project-related construction sites, and possible emissions of particulates, metals, and minor amounts of hydrogen chloride, sulfur dioxide, and oxides of nitrogen. In addition, there will be temporary increases in carbon monoxide if sludge disposal is to be accomplished through incineration for the purpose of power generation (102). However, it is likely that the sludge incineration will not take place within the proposed project area and will have no effect on air quality in the proposed project area.

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Secondary Impacts

The extension of MSD service into the proposed project area through implementation of either the regional alternative or the subregional alternative would accommodate population growth, which would be accompanied by secondary impacts on various air quality parameters. For the purpose of this analysis, it is assumed that the no action alternative would be accompanied by zero population growth. This alternative, therefore, would result in a different set of secondary air quality impacts. This section will project known or estimated 1975 emissions of carbon monoxide, hydrocarbons, oxides of nitrogen, sulfur dioxide, and particulates within the proposed service area to future years for each alternative by applying population growth and emission factor ratios. Projected pollutant emissions will then be related to worst case pollutant concentrations through the use of the Appendix J $HC-O_x$ relationship for photochemical oxidants, and the Modified Rollback Model for the other air pollutants (103). Air quality projections associated with the regional and subregional alternatives will then be compared with the air quality projections associated with the no action alternative.

The following major assumptions were used in the application of air quality models:

1) Carbon monoxide, hydrocarbon, oxides of nitrogen, sulfur dioxide, and particulate emission rates from light duty gasoline vehicles, heavy duty gasoline vehicles, and heavy duty diesel powered vehicles were projected according to the methods specified in the USEPA's "Compilation of Air Pollutant Emission Factors" (104). Based on Vehicle Miles Traveled (VMT) projections in CAPM, "The Community Aggregate Planning Model and Its Application in the St. Louis Area", if the regional and subregional alternatives are chosen, these vehicular emission sources will increase in the proposed project area at the rate illustrated in Figure 34 (105). Under the no action alternative, use of these vehicular emission sources within the proposed project area is projected to remain constant at 1975 levels.

2) It is assumed that pollutant emissions from railroad operations in the proposed service area will remain at their 1975 levels regardless of which alternative is chosen.

3) Under the regional and subregional alternatives, pollutant emissions from industrial sources are projected to increase proportionally with projected

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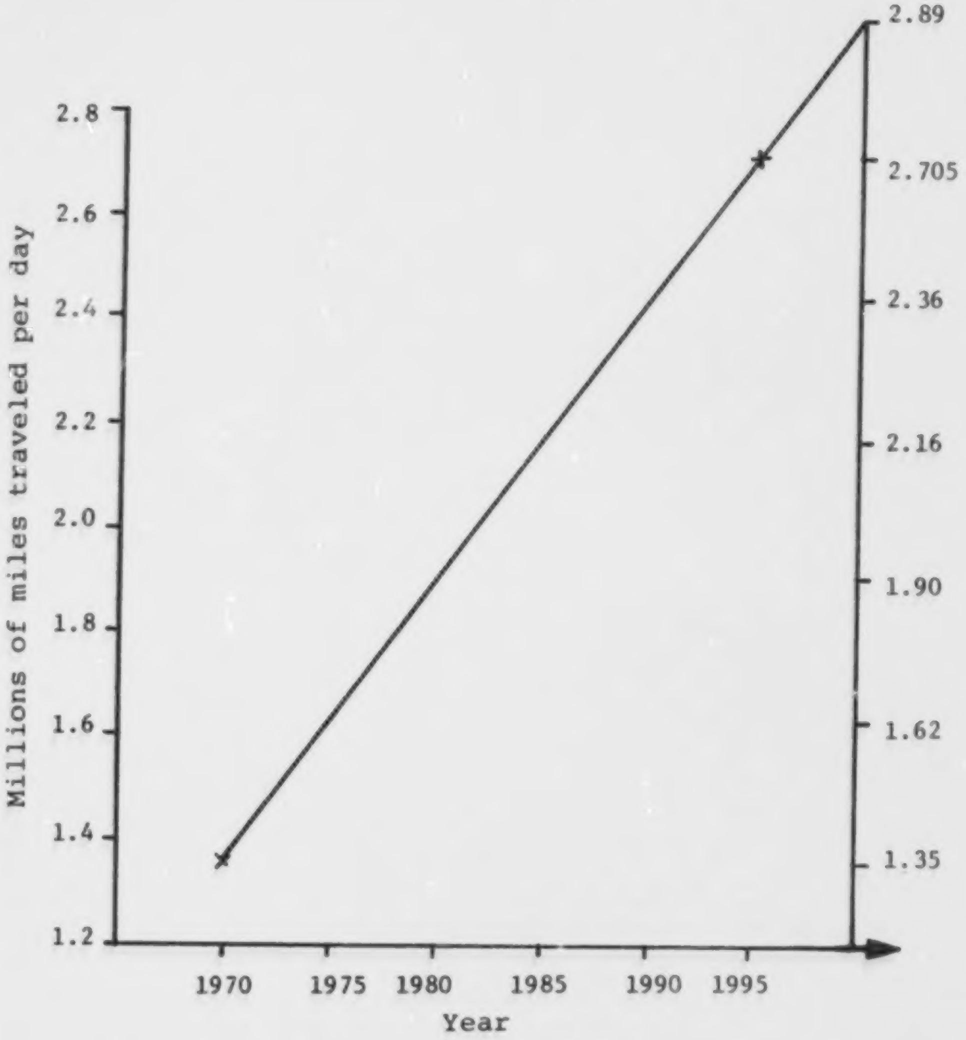

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FIGURE 34

PROJECTED VMT IN THE PROPOSED PROJECT AREA, MILLIONS OF MILES PER DAY

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industrial land use, as illustrated in Figure 35 (106). Under the no action alternative, pollutant emissions from industrial sources are projected to remain at their 1975 levels.

4) Pollutant emissions from power generation are projected to increase proportionally with projected population within the proposed project area under the regional and subregional alternatives. Population projections are illustrated in Figure 36. It is assumed that under the no action alternative, emissions from power generation in the proposed project area will remain constant at 1975 levels.

5) It is assumed that under the regional and subregional alternatives, pollutant emissions resulting from residential, commercial, or institutional fuel combustion will increase proportionally with projected population within the proposed project area. It is assumed that under the no action alternative, emissions from fuel combustion will remain constant at 1975 levels.

6) Hydrocarbon emissions from gasoline storage and handling were projected for the regional and subregional alternative according to the methods specified in "Compilation of Air Pollutant Emission Factors" Fuel usage was estimated at an average of 12 miles per gallon (mpg). VMT projections are illustrated in Figure 34. The methodology used assumed the emission rate would be 21 pounds per thousand gallons. It is assumed that under the no action alternative, hydrocarbon emissions will remain constant at 175 levels.

7) Emissions from solid waste disposal including municipal incineration and open burning are projected to increase proportionally with population increases under the regional and subregional alternatives. If the no action alternative is implemented, emissions from solid waste disposal are projected to remain at their 1975 levels.

Annual emission projections for each pollutant parameter of interest are presented in Figures 37 through 41. In these figures, emission rates associated with the regional and subregional alternatives are compared with emission rates associated with the no action alternative. The secondary impacts of the various alternatives on the air quality of the proposed project area are discussed, in terms of each of the air pollutants of interest, in the following paragraphs.

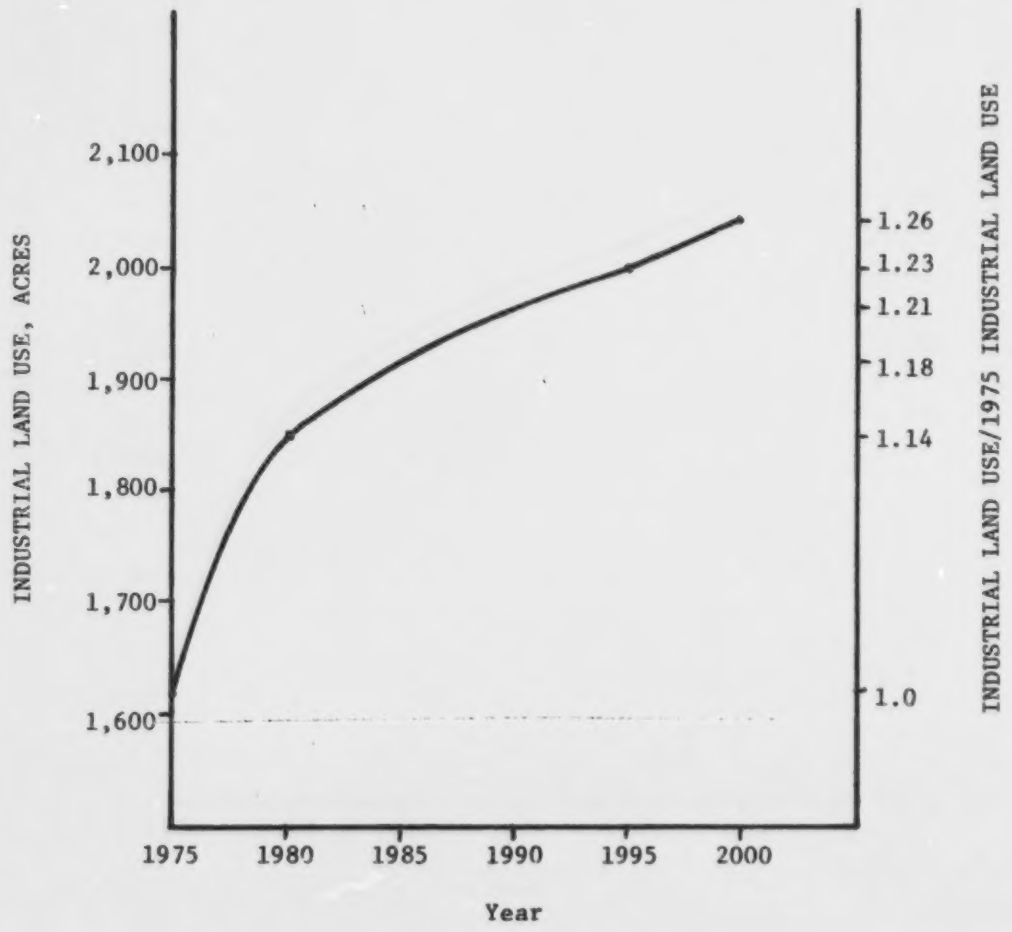

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FIGURE 35

PROJECTED INDUSTRIAL LAND USE (ACRES)

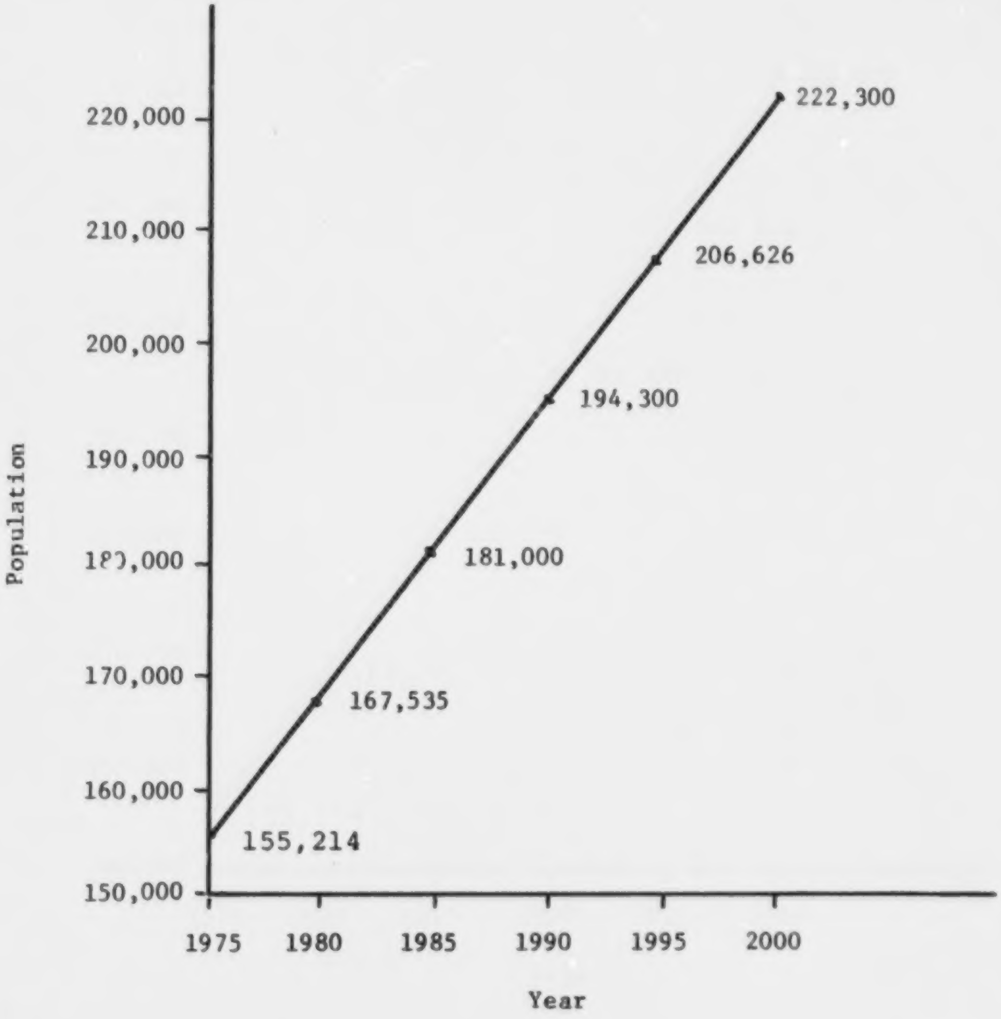

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FIGURE 36

PROPOSED PROJECT AREA
POPULATION PROJECTIONS

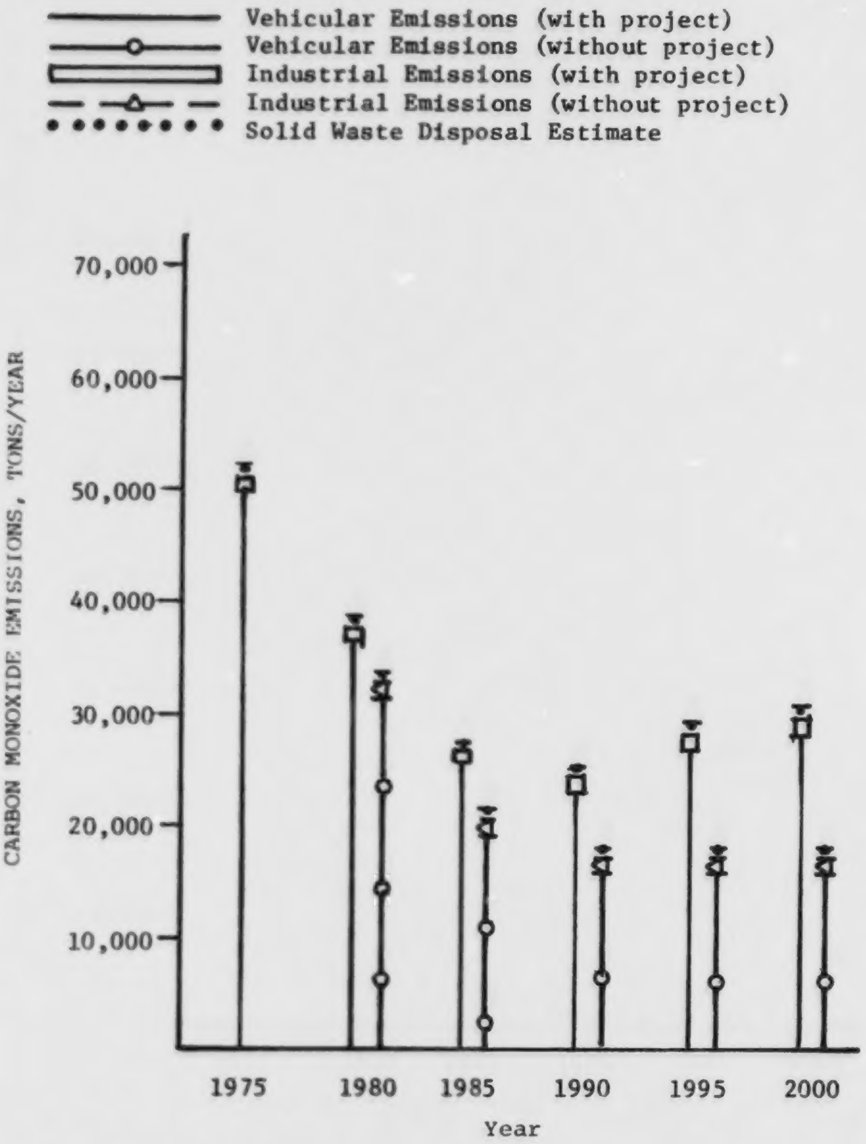

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FIGURE 37

1975 CARBON MONODIXE EMISSIONS
AND PROJECTIONS (TONS/YEAR)

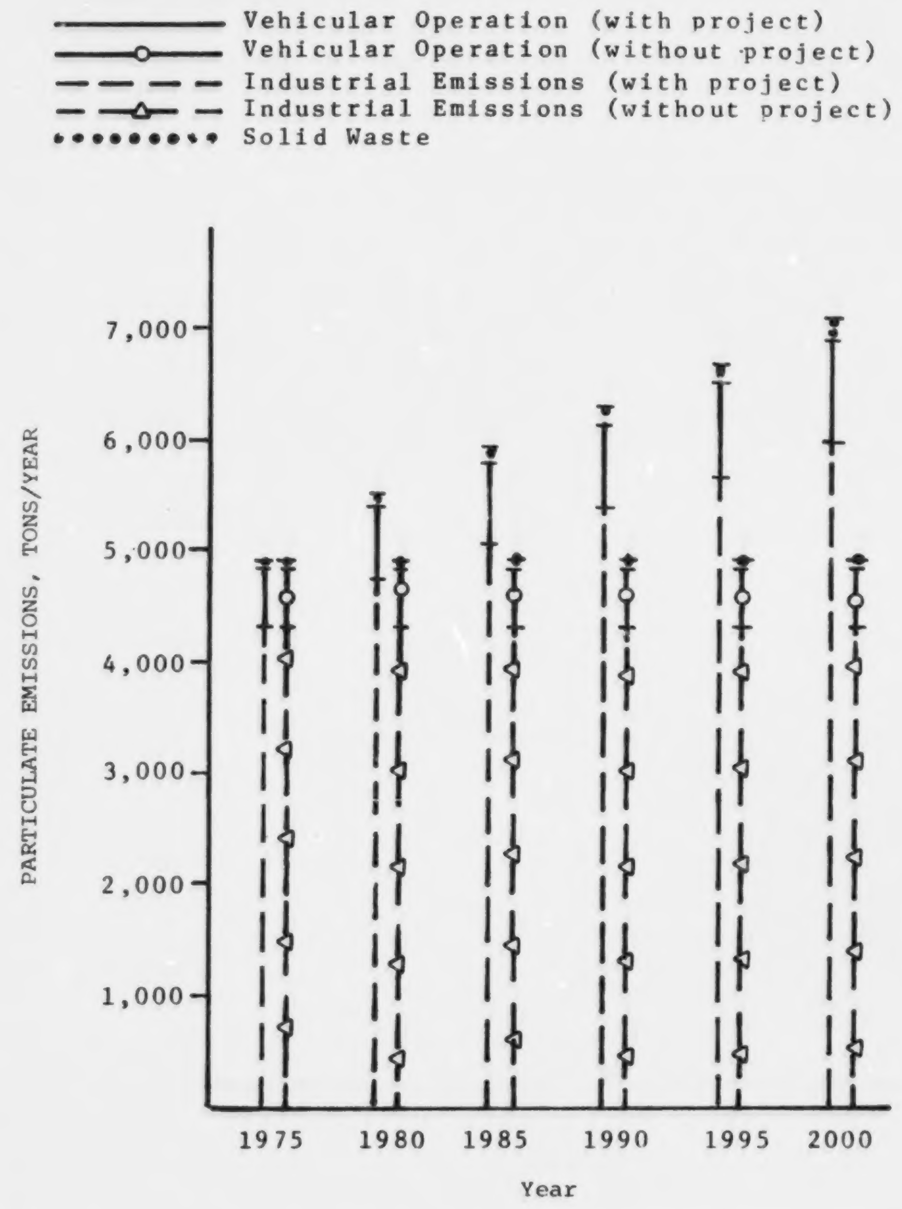

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FIGURE 38

PARTICULATE EMISSIONS
AND PROJECTIONS

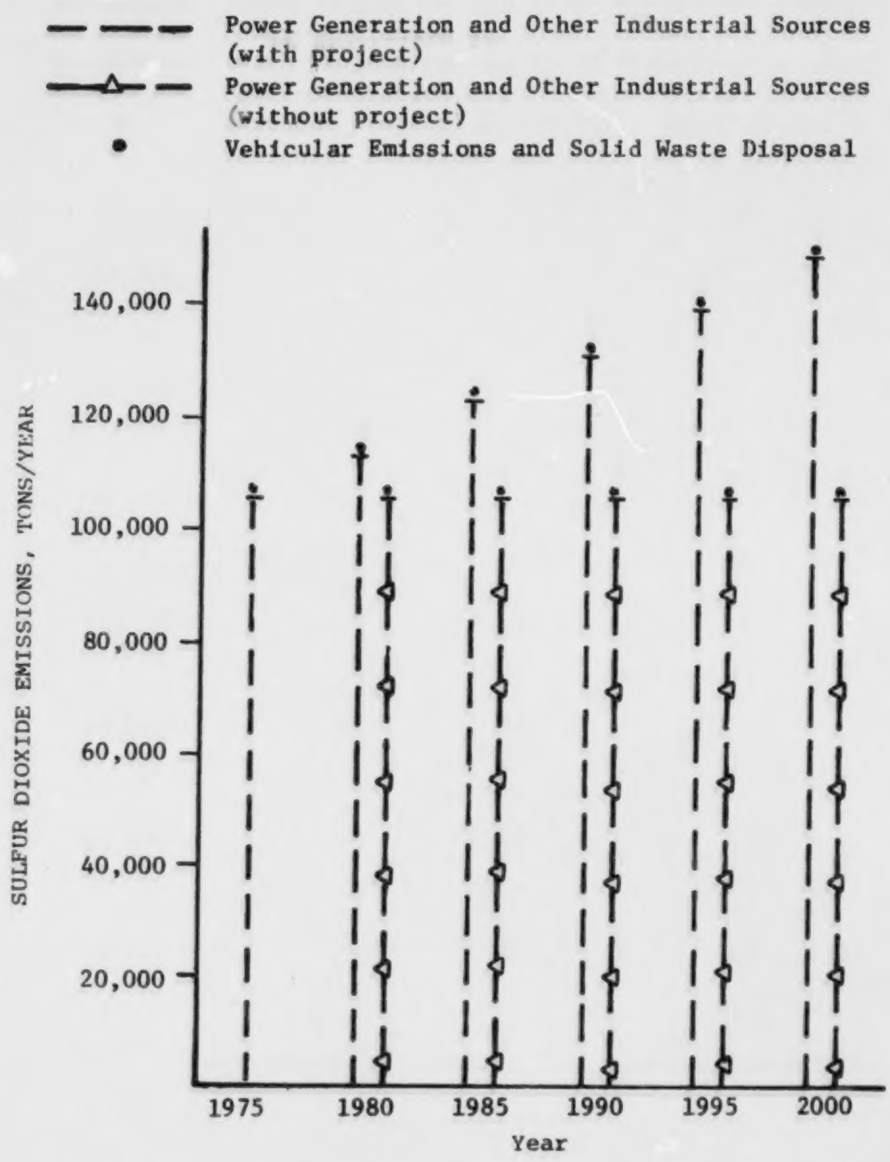

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FIGURE 39

SULFUR DIOXIDE EMISSIONS (TONS/YEAR)
AND PROJECTIONS

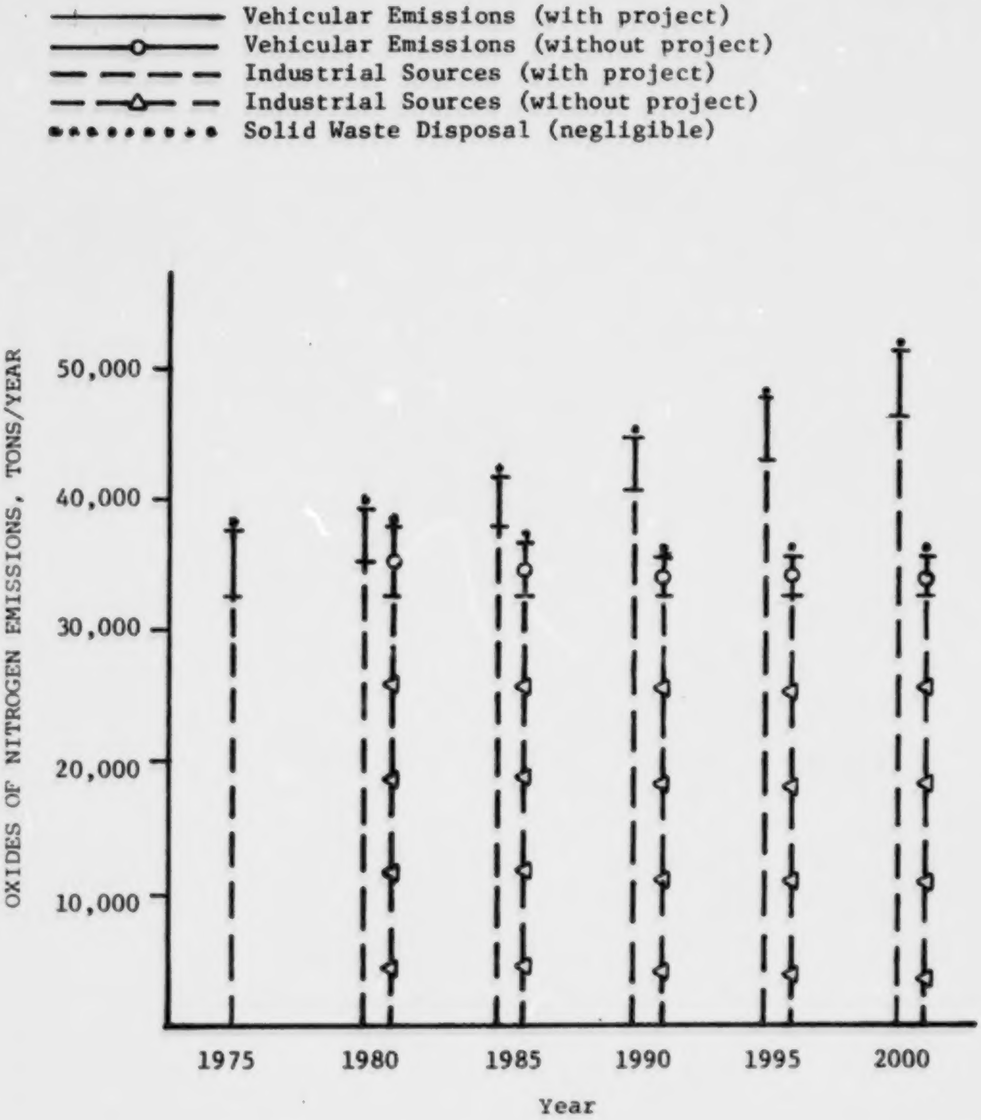

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FIGURE 40

OXIDES OF NITROGEN
1975 EMISSIONS AND PROJECTIONS
(TONS/YEAR)

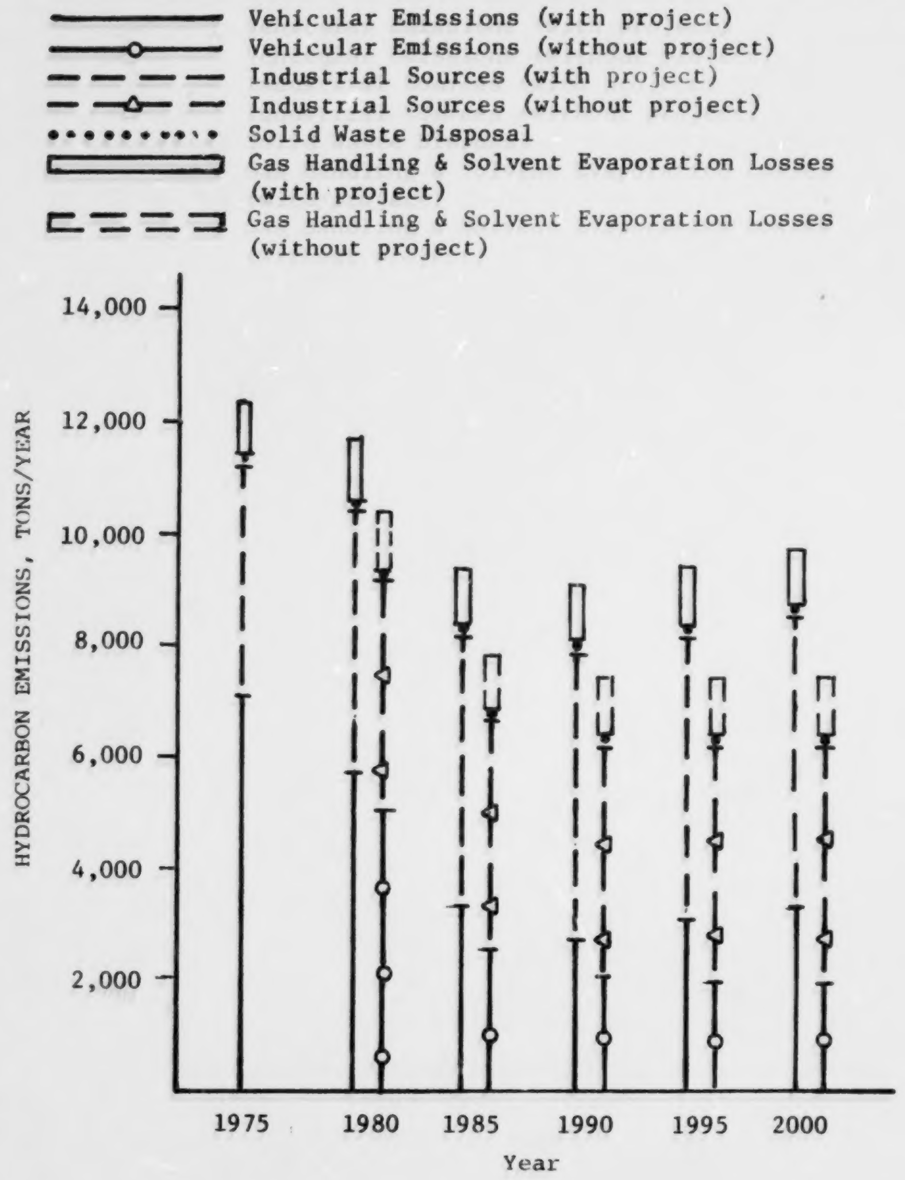

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FIGURE 41

1975 HYDROCARBON EMISSIONS AND PROJECTIONS (TONS/YEAR)

Carbon Monoxide - Carbon monoxide emissions in the proposed project area result primarily from the operation of automobiles, trucks, and buses. The 1975 emissions and projections for future years within and without the proposed project are illustrated in Figure 37. If the regional or subregional alternative is implemented, the accompanying effects of increased vehicular emissions are projected to be more than offset by the use of late model cars equipped with efficient pollution control devices. Total carbon monoxide emissions are anticipated to decrease steadily from the present time to the year 1990, with a slight increase thereafter. Results of rollback modeling indicates that both 1-hour and 8-hour maximum carbon monoxide concentrations can be expected to range from 15 parts per million (ppm) in 1980 to 10 ppm in 1990. The 1-hour standard is 35 ppm, and the 8-hour standard is 9 ppm. Therefore, according to projections, the maximum 1-hour concentration which will accompany the regional or subregional alternative will be well below the maximum allowable; however, the 8-hour standard would not be attained until the year 2000. Rollback modeling indicates that maximum 1-hour and 8-hour carbon monoxide under the no action alternative would range from 13 ppm in 1980 to 7 ppm in 1990. This would permit the achievement of the 8-hour 9 ppm standard by 1984.

Total Suspended Particulates - The annual geometric mean standard for total suspended particulates is 75 μg/m³, and the 24-hour maximum standard is 260 μg/m³. Results of rollback modeling indicate that if the regional or subregional alternative is selected, annual geometric mean concentrations can be expected to be as high as 177 μg/m³, and 24-hour concentrations can be expected to be as high as 706 μg/m³ by the year 2000. Projections for the no action alternative are not much lower, at 134 μg/m³ for the annual geometric mean and 506 μg/m³ for the 24-hour concentration. These projected violations are worst case projections for receptors near individual sources and do not reflect average conditions in the proposed project area.

Sulfur Dioxide - Sulfur dioxide concentrations within the proposed project area are caused by emissions at power generation facilities at 8200 Fine Street as well as transported sulfur dioxide from other power generation facilities and other sources outside the proposed project area. Emissions projections shown in Figure 39 assume that, as a worst case, pollution from these sources will not decrease significantly. Based on this assumption, rollback modeling of air quality accompanying the regional and subregional alternatives indicates a maximum 24-hour sulfur dioxide concentration of 0.17 ppm, and a maximum annual arithmetic mean concentration of 0.04 ppm, both around the year 2000. Both of these projections exceed the standards of 0.14 ppm 24-hour maximum and 0.03 ppm annual arithmetic mean. Rollback modeling of air quality for the no action alternative results in a predicted 24-hour maximum of 0.12 ppm, and a maximum predicted annual arithmetic mean of 0.03 ppm.

Oxides of Nitrogen - Primary sources of this pollutant include power generation facilities and transportation sources, as shown in Figure 40. The annual arithmetic mean standard of 0.05 ppm was equalled in 1974 at 5962 S. Lindbergh. Rollback modeling of air quality associated with the regional and subregional alternatives indicates a maximum annual arithmetic mean of 0.07 ppm by the year 2000. Modeling of the no action alternative indicates a maximum annual arithmetic mean of 0.05 or less through the year 2000.

Photochemical Oxidants - These pollutants are not directly emitted into the atmosphere, but result from chemical transformations of hydrocarbons, oxides of nitrogen, and oxygen in the presence of sunlight. The reactions take 1 hour or more, during which transport and dilution can occur. Use of the Appendix J HC-O_x relationship assumes that hydrocarbons are the primary reactant in the transformation, and that photochemical oxidant concentrations are directly proportional to hydrocarbon emissions. Emissions of this pollutant within the proposed project area result primarily from vehicular operations and industrial activities, such as dry cleaning operations, automotive painting, and gasoline storage and transfer. The photochemical oxidant standard of 0.08 ppm is often exceeded within the proposed project area. Results of modeling indicate that a steady decline in concentrations of photochemical oxidants can be expected from now until the year 2000 as control strategies are implemented and begin to show results. However, it is projected that hydrocarbon emissions will not be reduced sufficiently enough to achieve the oxidant standard. Violations are expected both within and outside the proposed area.

As the preceding paragraphs illustrate, levels of carbon monoxide, total suspended particulates, sulfur dioxide, oxides of nitrogen, and hydrocarbons are all expected to be in excess of federal standards at some point in the project's life. These excesses are projected to be exacerbated by the development expected to accompany implementation of either a regional or a subregional plan. Non-achievement of these standards should be regarded as detrimental to the health and welfare of the populace of the affected area and could result in developmental constraints through the mechanisms discussed in Chapter 3. Since the proposed project would be phased to accompany development (including modular design of treatment plants as well as phased sewer-line construction), halting of development in the project area would result in non-implementation of subsequent project phases.

IMPACTS ON WATER QUALITY

A dynamic water quality simulation model was used to assess the impacts of various wastewater management alternatives on water quality in the Meramec River. The model used was the Hydrocomp Water Quality model (107). The Hydrocomp model had previously been calibrated and verified for the Meramec River as part of the 208 planning process in the St. Louis area. The model was applied to the water quality assessment of impacts for the 201 Facilities Plan for the Lower Meramec Basin by the East West Gateway Coordinating Council in cooperation with their contractor, CH_2M-Hill, Inc. and the various parties involved in the 201 Planning process.

The model was used to simulate water quality in the Meramec River under three alternative wastewater management programs:

1) No Action - No future wastewater plant construction or improvement

2) Regional System - Construction of a single regional treatment facility at the mouth of the Meramec

3) Subregional System - Construction of nine treatment facilities along the Lower Meramec

The model was used to simulate conditions in the year 2000. It is important to note that the water quality modeling program, since it was carried out in coordination with 208 Planning, is based on a set of assumptions (used in the 208 Planning process) which are not the same assumptions used in the analysis of other impacts in this EIS. In all sections of this EIS, except for water quality, it was assumed that no growth would occur in the project area (due to a construction ban) if one of the project alternatives was not implemented. This assumption, in reality, results in the comparison of existing conditions to future conditions with a project. The assumption used in the water quality modeling (the same as that used in the 208 process) was that growth and development would occur in the project area under all alternatives, including the no action option. The basic philosophies underlying these two assumptions are: 1) the EIS assumption (no-project equals no growth) provides an analytical tool for measuring impacts; while 2) the 208 assumption (growth under all alternatives) provides information on projected growth and thereby establishes the levels of services which will be required under future conditions.

Hydrocomp Model

The Hydrocomp model is an extension of the Stanford Watershed model (108). The Stanford Watershed model was designed to similate the hydrologic cycle in a watershed. Historical precipitation and other meteorological parameters are input to the model. The model performs a detailed accounting of the fate of the precipitation and eventually predicts stream flows on an hourly basis. The Stanford Watershed model can, therefore, be used to simulate stream hydrographs resulting from actual rainfall events.

Hydrocomp, Inc. has extended the Stanford Watershed model to include water quality as well as water quantity considerations. The model is dynamic in that it can simulate water quality at hourly intervals. It is also an ecologic model since it models interactions between several levels of biological communities, including phytoplankton, zooplankton, benthic algae, and the benthos. The model can simulate the following parameters:

1) Temperature
2) Total dissolved solids (TDS)
3) Dissolved oxygen (DO)
4) Carbonaceous biochemical oxygen demand (BOD)
5) Coliforms (total, fecal, and fecal streptococci)
6) Algae/Chlorophyll-a
7) Zooplankton
8) Ammonia
9) Nitrite
10) Nitrate
11) Total nitrogen
12) Phosphate
13) Potential phosphorous
14) Conservative materials (i.e., metals, chloride, etc.)

The stream to be modeled is first divided into a series of reaches. The Hydrocomp model treats each reach as a completely mixed reactor. In each time step, material is transported into and out of each reach by advection and the effects of biological and chemical processes are computed.

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The model is one-dimensional. Water quality variations along the direction of flow are modeled. Uniform conditions are assumed in the lateral (across the stream) and in the vertical (throughout the depth of the stream) directions.

The model can also simulate the behavior of an impoundment. Stratification effects can be modeled by dividing the impoundments into three horizontal layers. Mixing between layers can be accommodated. The impoundment feature was not needed to model the Lower Meramec.

Model Application

The Hydrocomp model was applied to the entire Meramec River Basin by CH_2M-Hill as a part of the 208 Planning process for the St. Louis metroplitan area. The previously calibrated and verified model was used to evaluate impacts of the 201 alternatives on water quality in the Lower Meramec.

Figure 42 presents the stream reaches used to model the Lower Meramec and the tributary areas. The reaches used to model the Lower Meramec are presented in Table 48 while the tributary areas are described in Table 49.

Upstream conditions used in all simulations of alternatives were the same. It was assumed that treatment plants upstream from the confluence of Keifer Creek with the Meramec would be improved to provide secondary treatment with nitrification and disinfection. In addition, it was assumed that provisions for the control of non-point pollutants in the upstream areas would be increased.

Outputs from the model included:

1) BOD (mg/l)

2) DO (mg/l)

3) Ammonia (mg/l as N)

4) Nitrate (mg/l as N)

5) Ortho phosphate (mg/l as P)

6) TDS (mg/l)

7) Temperature (°C)

8) Fecal coliform (MPN/100 ml)

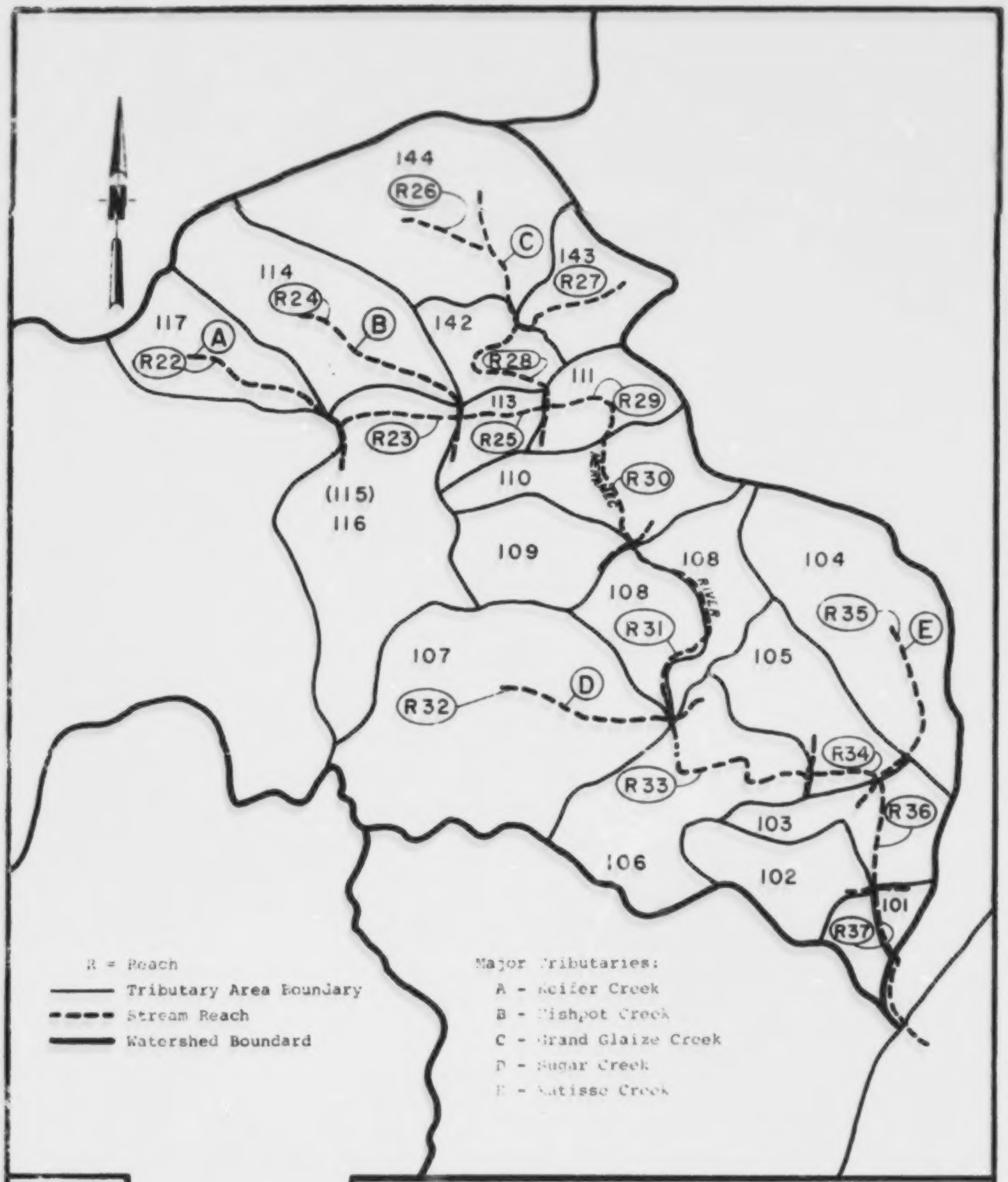
N
144
R26
C
143
R27
114
R24
B
117
A
R22
142
R28
111
R29
113
R23
R25
110
R30
MERAMEC
(115)
116
109
108
108
RIVER
104
R35
E
R31
105
107
D
R32
R34
R33
R36
103
102
106
101
R37
R = Reach
Tributary Area Boundary
Stream Reach
Watershed Boundard
Major Tributaries:
A - Keifer Creek
B - Fishpot Creek
C - Grand Glaize Creek
D - Sugar Creek
E - Matisse Creek

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FIGURE 42

LOWER MERAMEC STUDY AREA
REACHES AND TRIBUTARY AREA

24<

TABLE 48

DESCRIPTION OF MODEL REACHES IN THE LOWER MERAMEC STUDY AREA

Reach Number	Stream	Description	Length (mi)	Tributary Area (mi^2)
22	Keifer Creek	--	2.5	7.0
23	Meramec	Kiefer Creek to Fishpot Creek	2.1	10.1
24	Fishpot Creek	--	2.5	10.4
25	Meramec	Fishpot Creek to Grand Glaize Creek	2.1	1.8
26	Upper Grand Glaize Creek	--	2.9	14.4
27	Sugar Creek	--	1.4	5.6
28	Lower Grand Glaize Creek	--	2.0	3.6
29	Meramec	Grand Glaize Creek to I-44 Bridge	2.3	4.3
30	Meramec	I-44 Bridge to Fenton	2.9	8.7
31	Meramec	Fenton to Saline Creek	5.2	12.6
32	Saline Creek	--	4.5	17.8
33	Meramec	Saline Creek to I-55 Bridge	3.3	8.1
34	Meramec	I-55 Bridge to Mattese Creek	2.0	6.0
35	Mattese Creek	--	3.0	12.3
36	Meramec	Mattese Creek to Pomme Creek	3.0	5.9
37	Meramec	Pomme Creek to Mouth	1.7	9.6

TABLE 49

TRIBUTARY AREAS TO THE LOWER MERAMEC STUDY AREA

Reference Number	Watershed or Segment
101	Meramec (Mouth to Pomme Creek)
102	Pomme Creek
103	Meramec (Pomme Creek to Mattese Creek)
104	Mattese Creek
105	Meramec (Mattese Creek to Hwy I-55)
106	Meramec (Hwy I-55 to Saline Creek)
107	Saline Creek
108	Meramec (Saline Creek to Fenton Creek)
109	Fenton Creek
110	Meramec (Fenton Creek to Hwy I-44)
111	Meramec (Hwy I-44 to Grand Glaize Creek)
112	Grand Glaize Creek (See also #142, #143, and #144)
113	Meramec (Grand Glaize Creek to Fishpot Creek)
114	Fishpot Creek
115	Williams Creek (See also #116)
116	Meramec (Fishpot Creek to Kiefer Creek [includes #115])
117	Keifer Creek
142	Grand Glaize Creek (Below Sugar Creek)
143	Grand Glaize Creek (Sugar Creek Branch)
144	Grand Glaize Creek (Above Sugar Creek [excluding #143])

9) Fecal streptococci (MPN/100 ml)

10) Chlorophyll-a

11) Phytoplankton

12) Zooplankton

These parameters were simulated on an hourly basis and printed every four hours. In addition, stream flow was printed once a day.

The model was applied to two time periods. First, historical meteorological data were used to simulate summer of 1973 conditions. In addition, modirications were made to the 1963 historical record to produce a simulation run that approximated extreme low flow conditions (7 day - 10 year) in the Meramec River. For all three, alternative conditions projected for the year 2000 were overlayed upon the historic meteorological records.

Figure 43 shows the Meramec River discharge at the U.S. Geological Service gage at Eureka, Missouri for the summer of 1973 (109). Figure 44 presents similar data for the discharge of the Mississippi River at the St. Louis gage. The St. Louis gage is located above the confluence with the Meramec River. Both streams exhibit somewhat similar flow patterns. Flows were relatively high in June, and gradually decreased to typical summer low flow conditions during July and August. Increased flows result from storm events. In general, the Meramec's responses to storm events are more dramatic than the Mississippi's responses because the Meramec Basin is much smaller than the Mississippi drainage. The St. Louis International Airport's weather station precipitation records for the summer of 1973 are shown in Figure 45. By comparing Figure 43 and 45, it becomes apparent that the peaks in discharge correspond quite closely to rainfall events.

Two days were selected from the summer of 1973 for evaluation. July 18, 1973 was selected as being representative of conditions following a summer dry period. July 24, 1973 was selected as being reflective of conditions following a significant storm event following a dry period. This set of circumstances should enable conclusions to be drawn regarding the relative importance of non-point sources of pollution.

Description of Water Quality Aspects of the No Action Alternative

In order to make water quality projections for the no action alternative, estimates first had to be made for the quanitity and quality of wastewater discharged to the Lower Meramec in

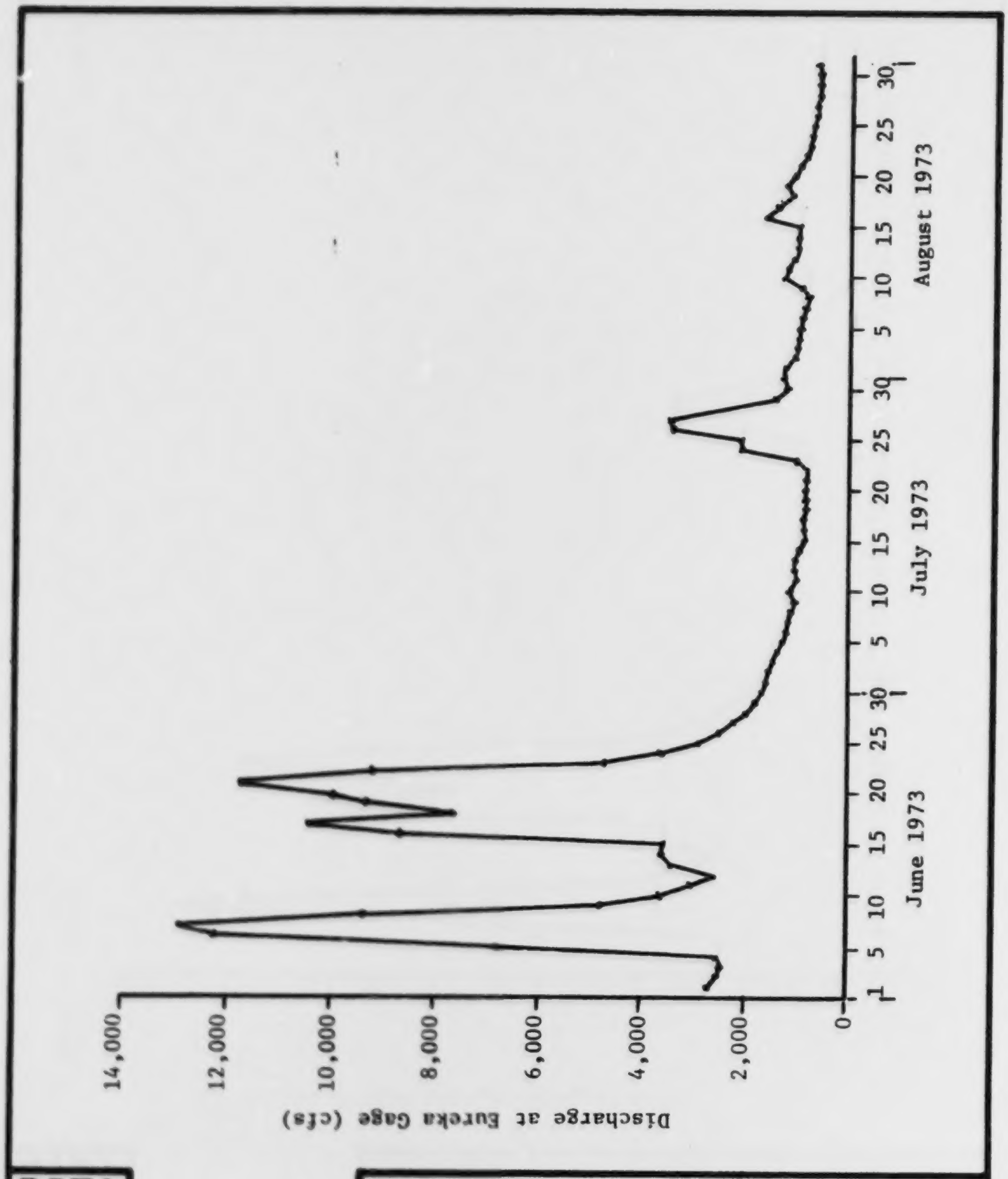

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FIGURE 43
MERAMEC RIVER DISCHARGE
AT EUREKA GAGE

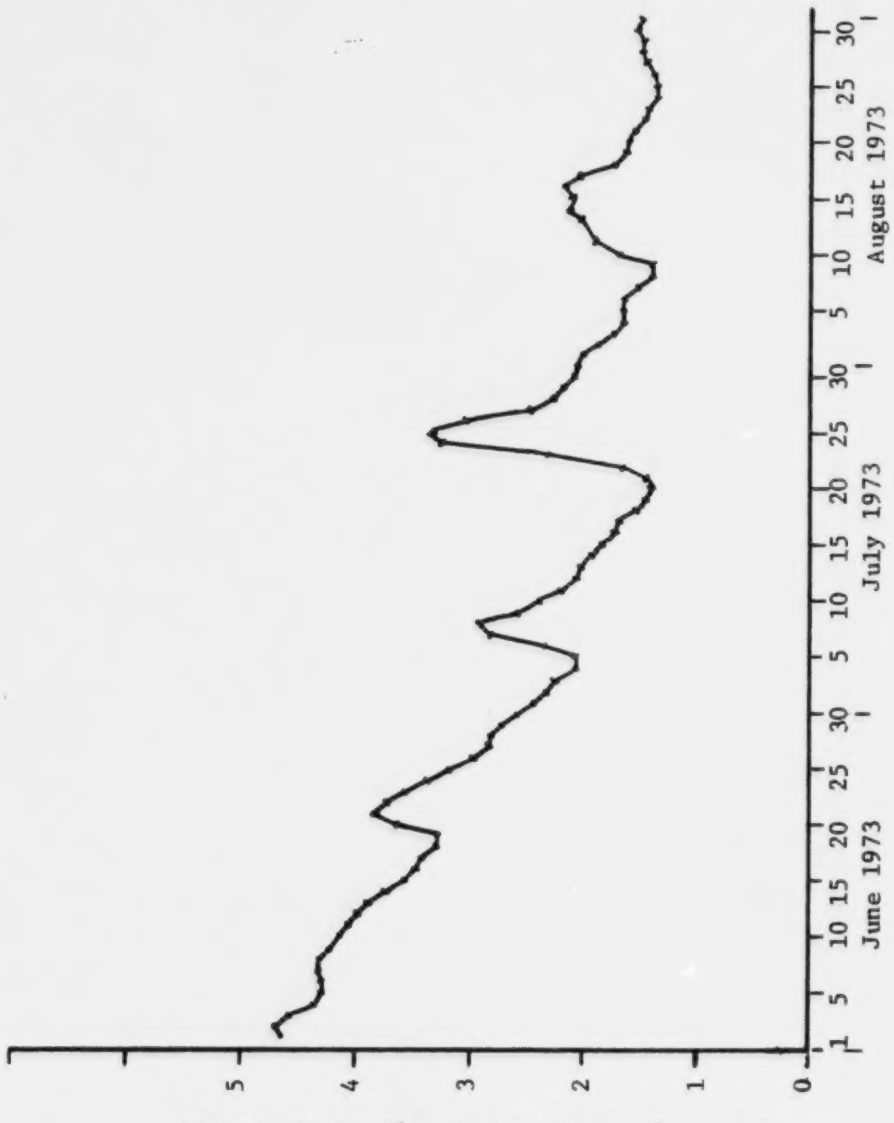

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FIGURE 44
MISSISSIPPI RIVER DISCHARGE
AT ST. LOUIS GAGE

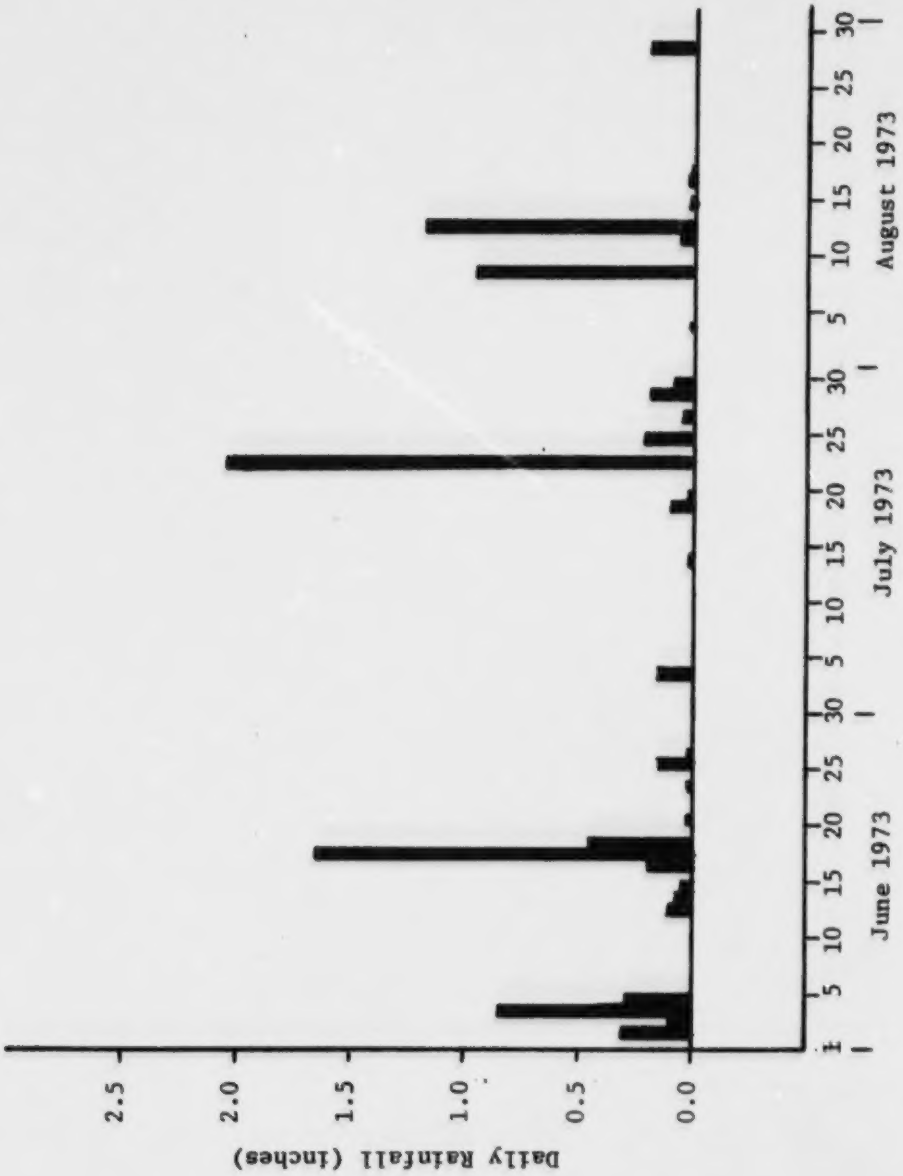

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FIGURE 45

DAILY PRECIPITATION PATTERN
AT ST. LOUIS INTERNATIONAL AIRPORT

the year 2000 under this alternative. Several basic assumptions were involved in developing input wastewater flows and concentrations:

1) The quantity of wastewater currently receiving treatment will continue to receive the same level of treatment through the year 2000.

2) Additional flows received at existing treatment facilities will not be treated prior to discharge.

3) No improvements will be made to existing treatment facilities and new facilities will not be constructed.

4) Pump stations pumping wastewater out of the Meramec Basin are currently operating at capacity.

5) Additional flows occurring at existing pumping stations pumping out of the basin will be spilled into streams tributary to the Meramec River.

The characteristics of untreated wastewater are shown in Table 50. The average concentration of a material in the total discharge (treated and untreated) is given by:

$$C_{discharged} = \frac{Q_{tr} \cdot C_{tr} + Q_{un} \cdot C_{un}}{Q_{tr} + Q_{un}}$$

Where: $C_{discharged}$ = Concentration in the total discharge to a reach

C_{tr} = Effluent concentration of wastewater receiving treatment

C_{un} = Concentration of untreated wastewater

Q_{tr} = Flow rate of treated wastewater

Q_{un} = Flow rate of untreated wastewater

Characteristics of treated wastewater discharges were developed during the 208 Planning process.

TABLE 50

UNTREATED WASTEWATER CHARACTERISTICS
SUMMER CONDITIONS

BOD	200 mg/l
Temperature	22°C
DO	0.0 mg/l
PO_4 as P	7.0 mg/l
NH_3 as N	25 mg/l
NO_3 as N	0.0 mg/l
TDS	500 mg/l
pH	7.3
Fecal Coliform	1×10^7 MPN/100 ml

Normal Summer Low Flow Conditions

The model was used to assess the water quality impacts of the three alternatives during typical summer low flow conditions. July 18, 1973 conditions were used in this evaluation.

The discharge was relatively uniform along the Meramec. Simulated flows were 1180 cfs at the I-44 bridge; 1150 cfs at Fenton; 1160 cfs at the mouth of Saline Creek; and 1190 cfs at the mouth of the Meramec.

Simulated fecal coliform concentrations are shown in Figure 46. Both the subregional and regional alternatives will result in low levels of coliforms, well within the water quality standards. The no action alternative will result in continued violation of state standards.

Figure 47 presents results of the temperature simulation. Temperatures resulting from the three alternatives were virtually identical. Diurnal fluctuations of less than 1.0°C were predicted. Temperatures ranged from 25.7°C at Keifer Creek to slightly less than 28°C at the mouth.

As shown in Figure 48, TDS was predicted to be fairly uniform at about 270 mg/l, increasing slightly in the downstream direction. The three alternatives have virtually the same impact.

Predicted BOD levels are shown in Figure 49. The no action alternative will result in an increase in BOD in the downstream direction as a result of organic waste discharges. Although BOD will increase with the subregional alternative, the increase will be significantly less than with the no action alternative. BOD will decrease slightly under the regional alternative due to the elimination of point sources in the lower Meramec.

Dissolved oxygen (DO) levels are relatively high in this section of the river, as shown in Figure 50. DO is well above the state standard of 5.0 mg/l. All three alternatives yield approximately the same DO level. Diel fluctuations are significantly reduced under the regional alternative.

Predictions for ammonia are shown in Figure 51. Ammonia concentrations are very low. Ammonia levels resulting from both the subregional and regional alternatives are significantly less than levels resulting from the no action alternative.

The un-ionized ammonia (NH_3) of total ammonia has been found to be the toxic form of ammonia. The current state standard places an upper limit of 0.1 mg/l on un-ionized ammonia as N while the proposed standard is only 0.02 mg/l. At a temperature of 30°C and a pH of 8.0, only about 7.5 percent of total ammonia is present in the toxic un-ionized form. Total ammonia

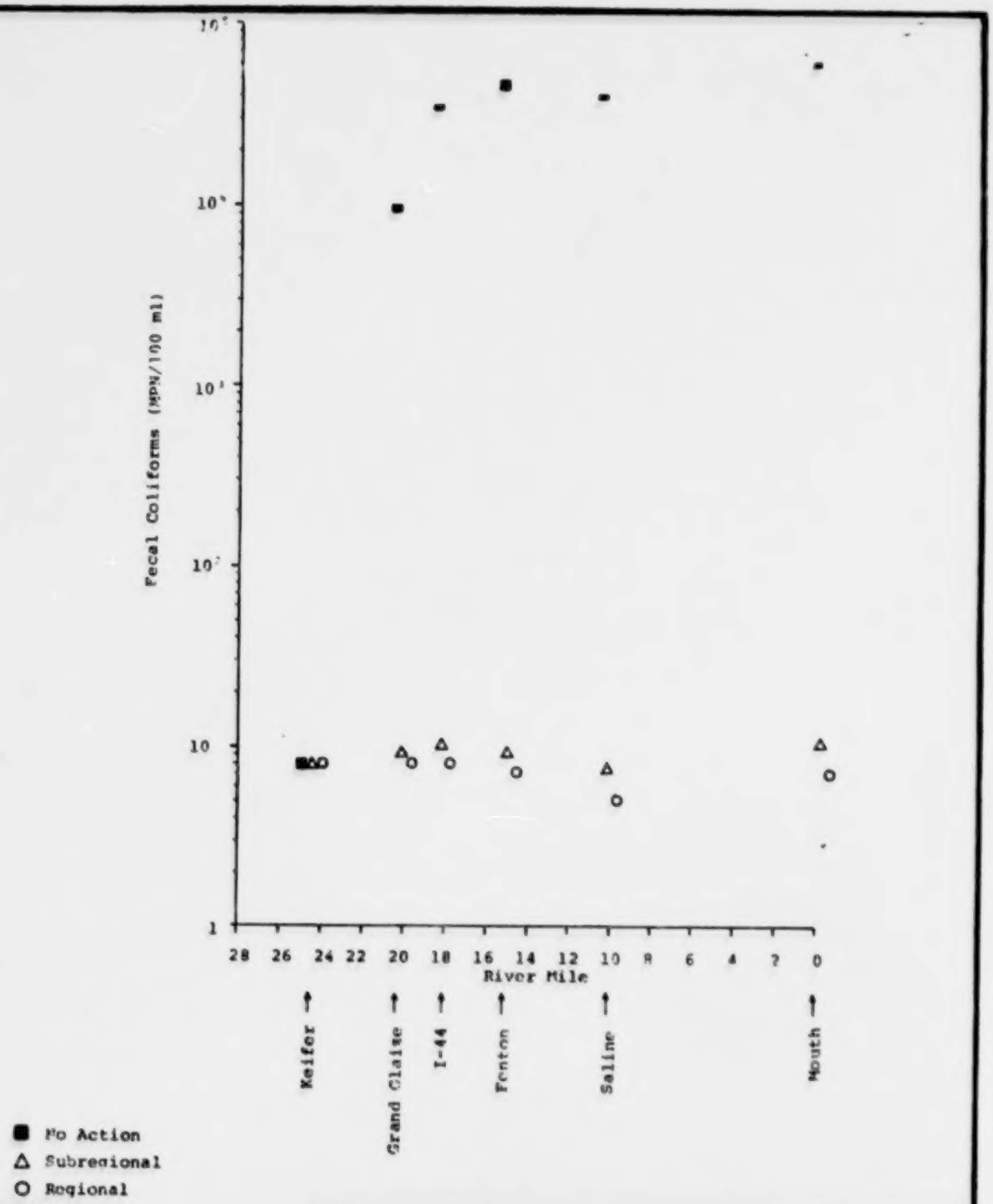

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FIGURE 46

FECAL COLIFORM VARIATIONS
JULY 18, 1973

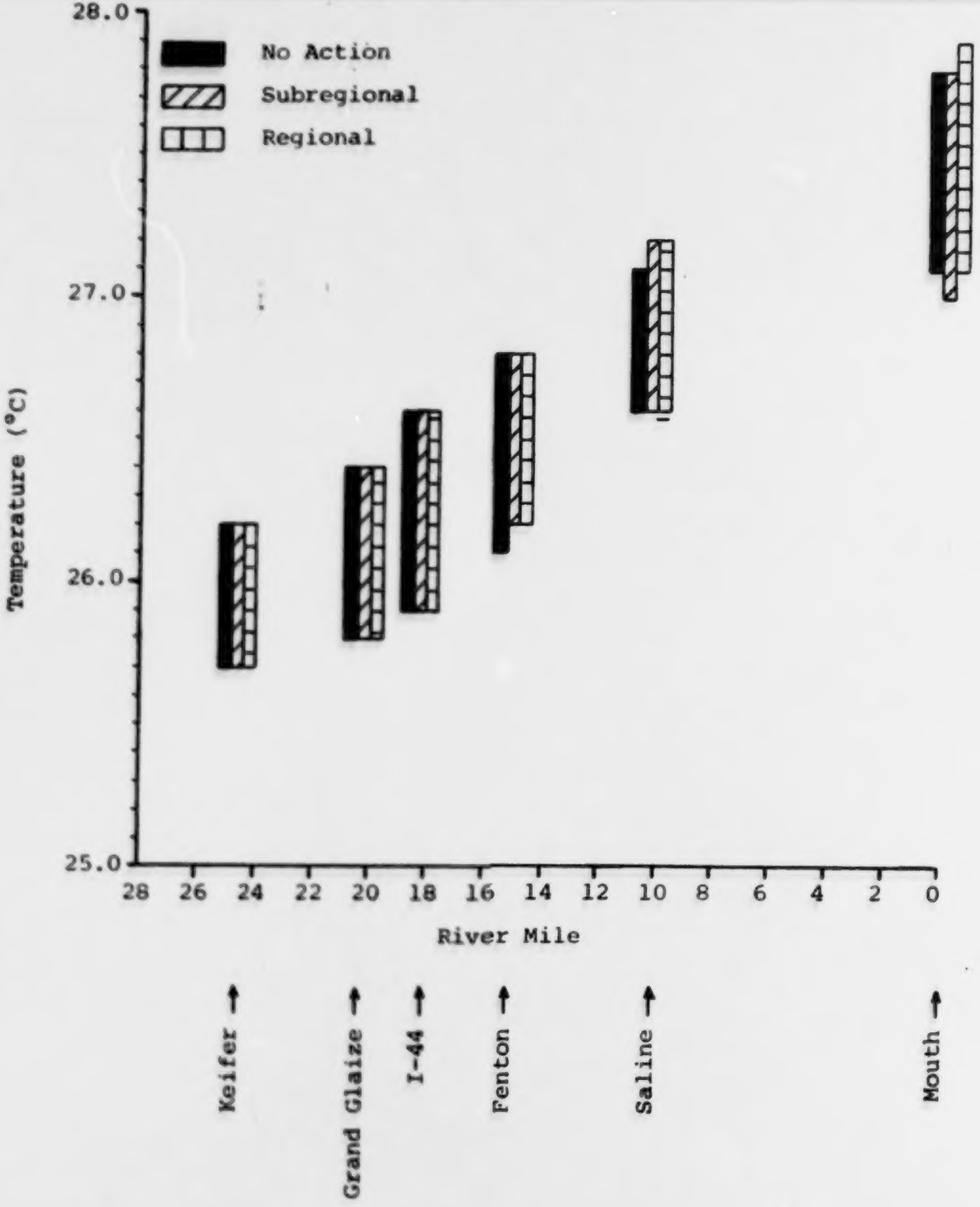

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FIGURE 47

TEMPERATURE VARIATIONS
JULY 18, 1973

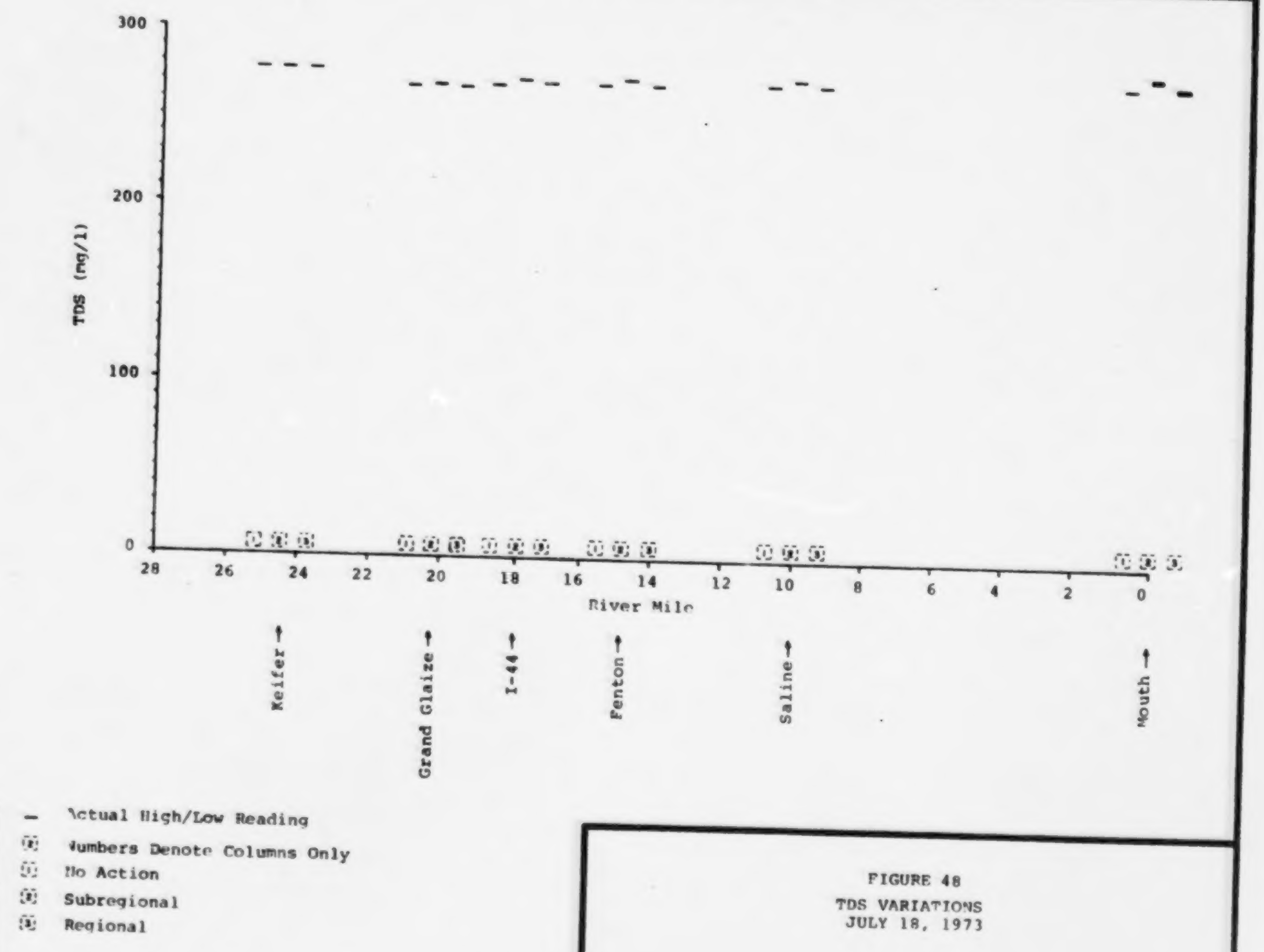

FIGURE 48
TDS VARIATIONS
JULY 18, 1973

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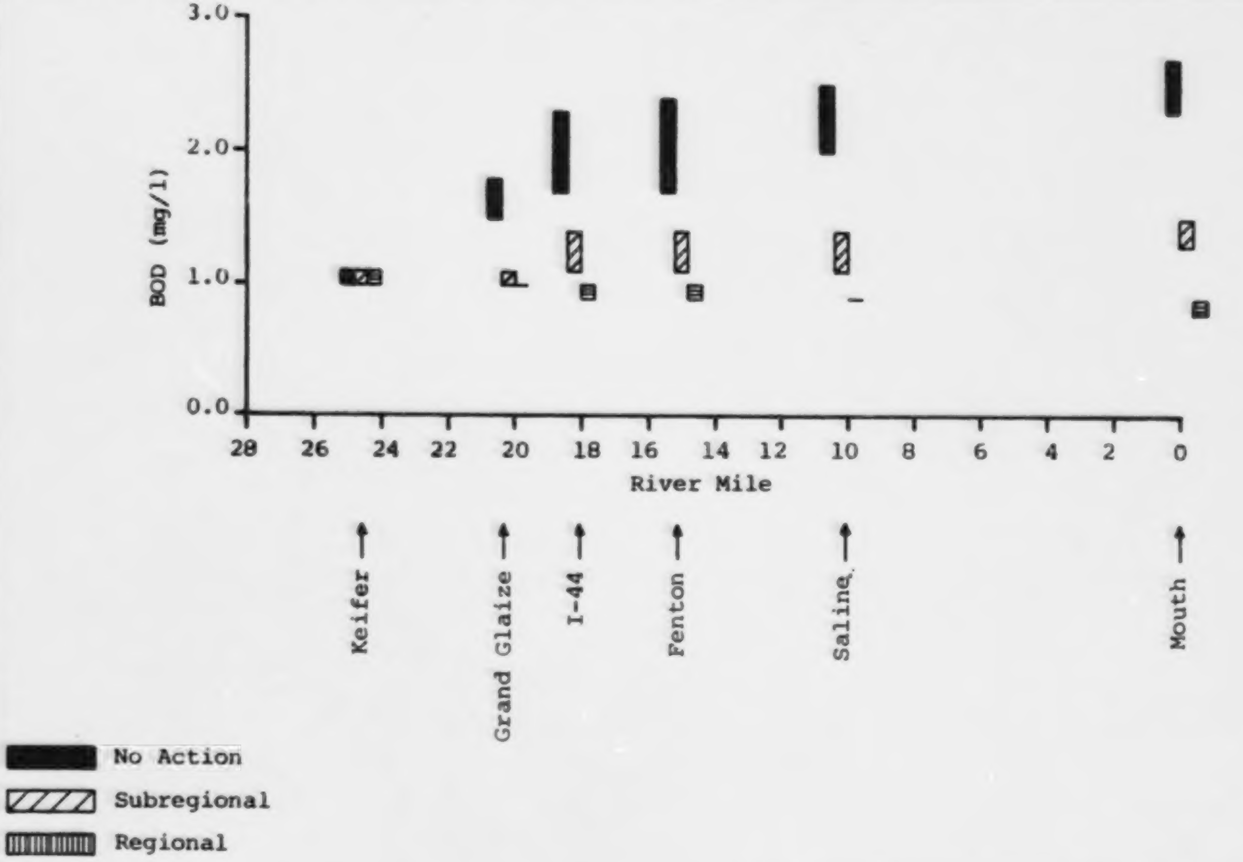

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FIGURE 49

BOD VARIATIONS
JULY 18, 1973

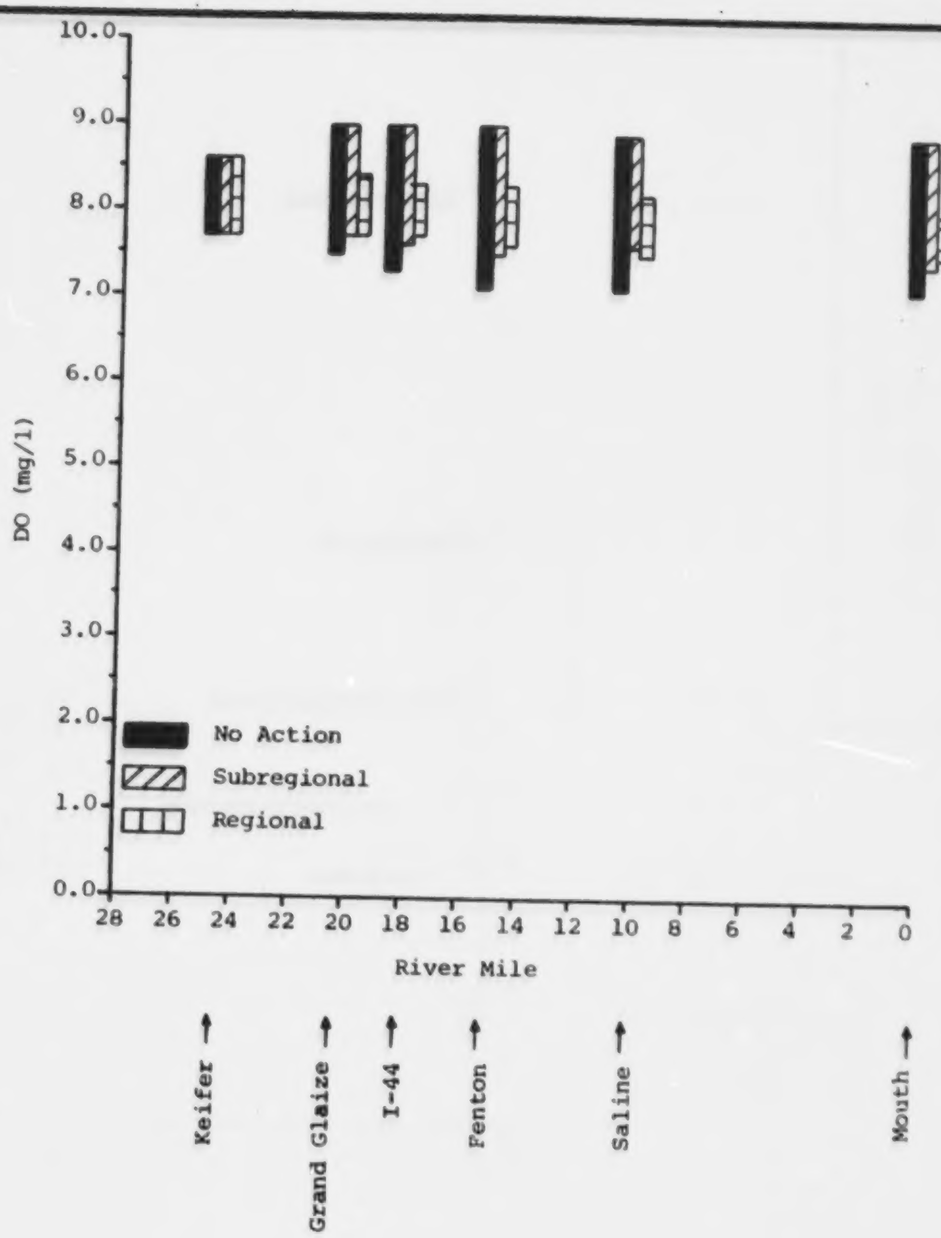

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FIGURE 50

DO VARIATIONS
JULY 18, 1973

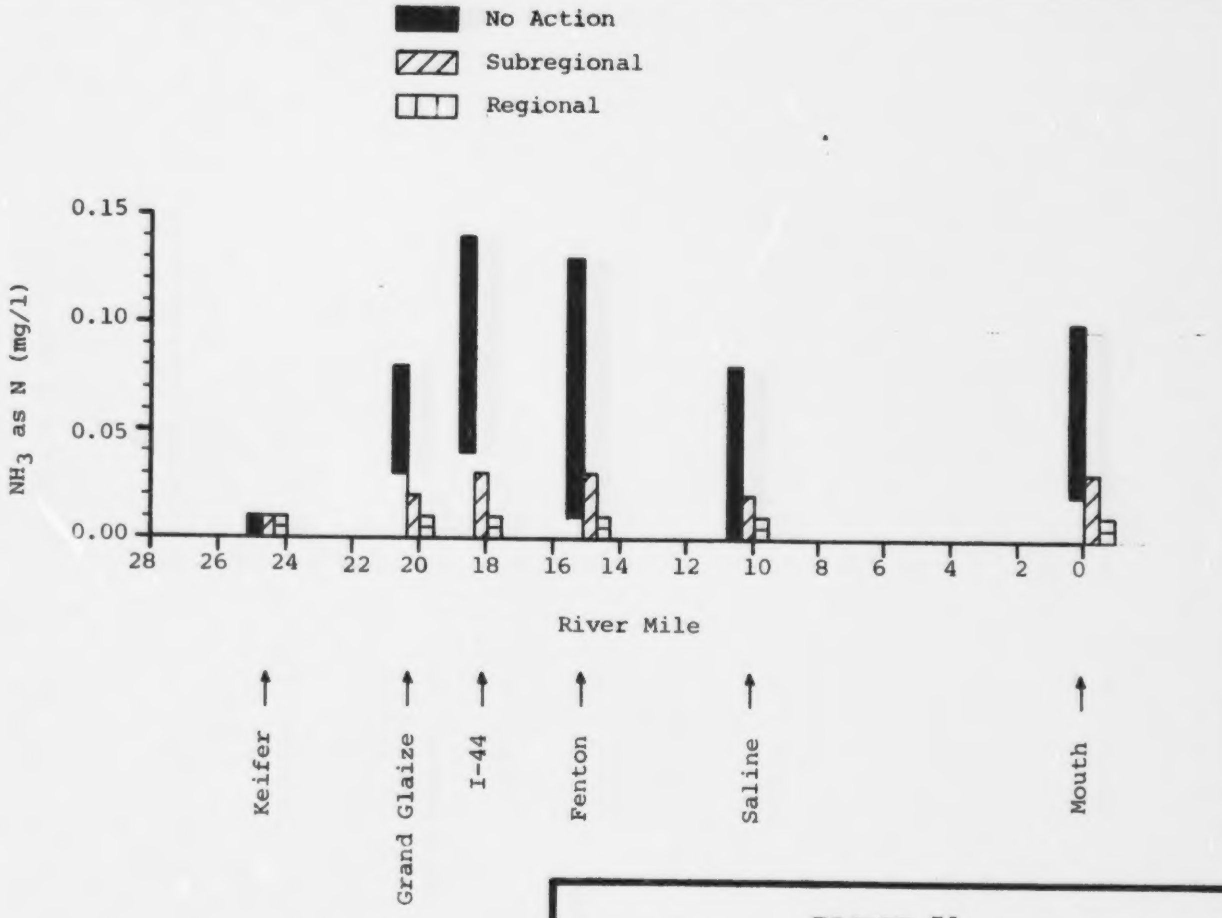

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FIGURE 51
AMMONIA VARIATIONS
JULY 18, 1973

would have to exceed 1.33 mg/l as N for the current state standard to be violated; or 0.27 mg/l for the more stringent proposed standard to be exceeded. The values predicted in Figure 51 present no problems in terms of ammonia toxicity.

Nitrate predictions are shown in Figure 52. Nitrates resulting from the regional alternative are very low since all point discharges to the Lower Meramec would be eliminated. Nitrates will increase in the downstream direction with the no action alternative as a result of nitrification of ammonia nitrogen. Nitrates resulting from the subregional alternative will be somewhat greater than for the no action alternative since the effluents will be nitrified prior to discharge. Neither of the alternatives will result in nitrate levels large enough to cause concern.

Predictions for phosphate are shown in Figure 53. The subregional and regional alternatives will result in significantly less phosphates than the no action alternative.

Figure 54 presents predictions for chloraphyll-a concentrations. This material is an indicator of the amount of algae present. Algae concentrations resulting from the subregional and regional alternatives will be significantly less than under the no action alternative. The elimination of discharges under the regional alternative will result in the lowest chloraphyll-a concentrations.

The subregional alternative will increase chlorine residuals in the Meramec by less than 0.07 mg/l. The no action and regional alternatives will not add chlorine to the Meramec.

Effect of a Rainfall Event

Figures 55 through 61 present simulated water quality conditions in the Meramec River at Fenton during July 1973. This simulation reflects the results of the regional alternative in the year 2000. The curves depict the range of diel fluctuations of water quality during this period. The impact of the rainfall event that occurred on July 23, 1973 is quite apparent. This section focuses on the relative impacts of the three alternatives during a rainfall event. July 24, 1973 conditions were used for comparison purposes.

Figure 55 presents the results of the wet weather simulation for fecal coliforms. Coliform counts resulting from the subregional and regional alternative are nearly identical. These two treatment alternatives will result in counts significantly lower than those resulting from the no action alternative. However, the differences between the treatment alternatives and no action alternative are not as dramatic as for the dry weather condition (See Figure 46).

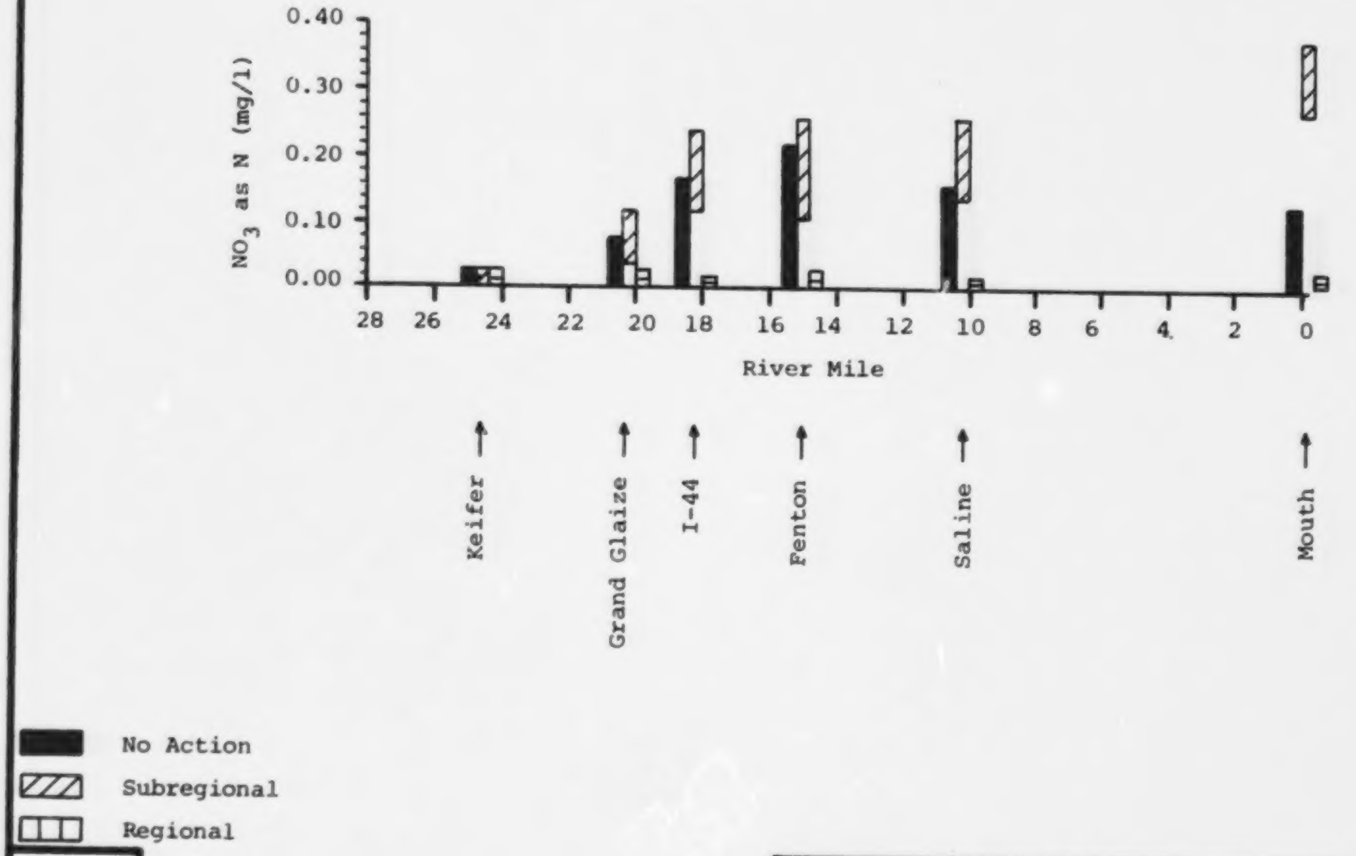

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FIGURE 52

NITRATE VARIATIONS
JULY 18, 1973

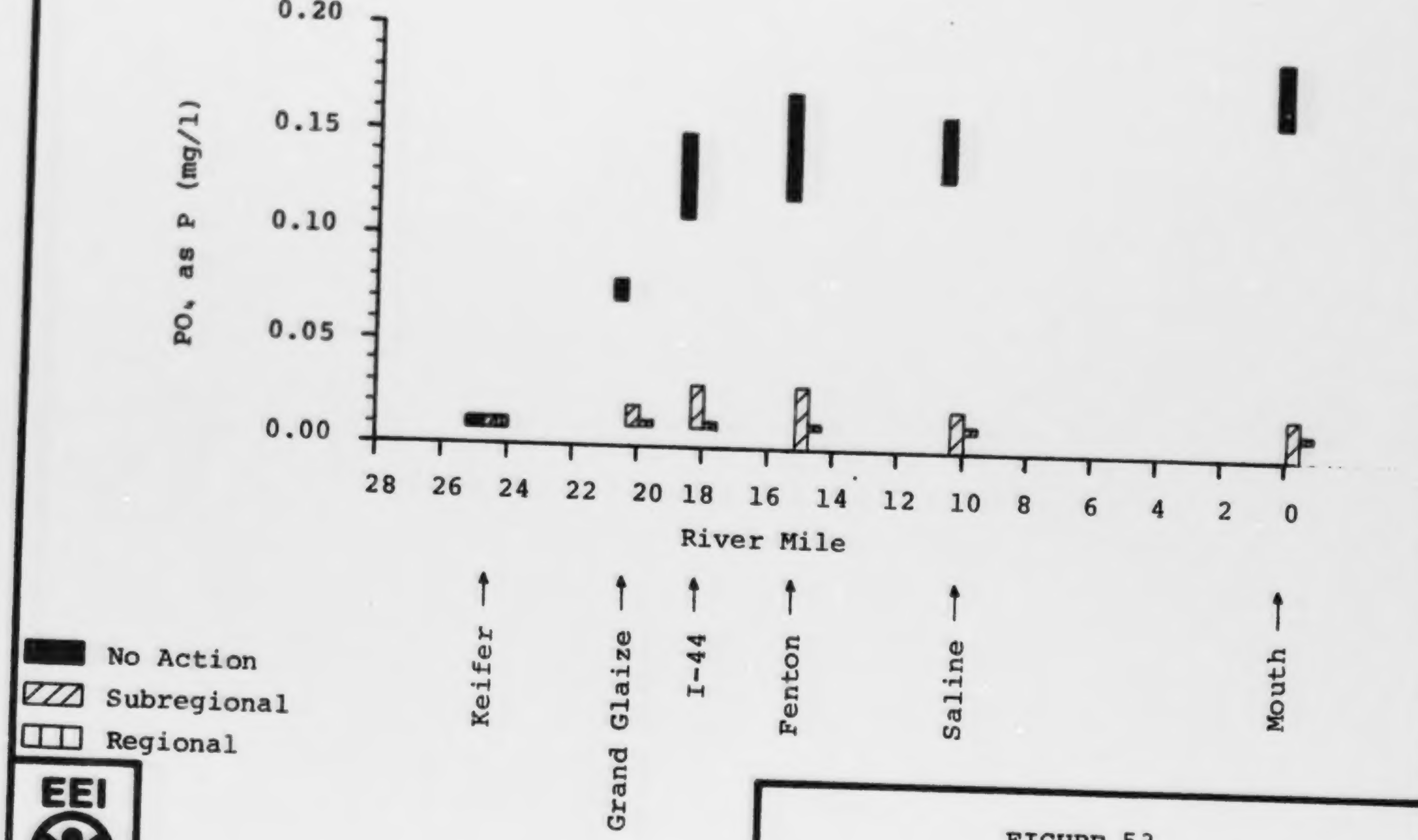

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FIGURE 53

PO_4 VARIATIONS
JULY 18, 1973

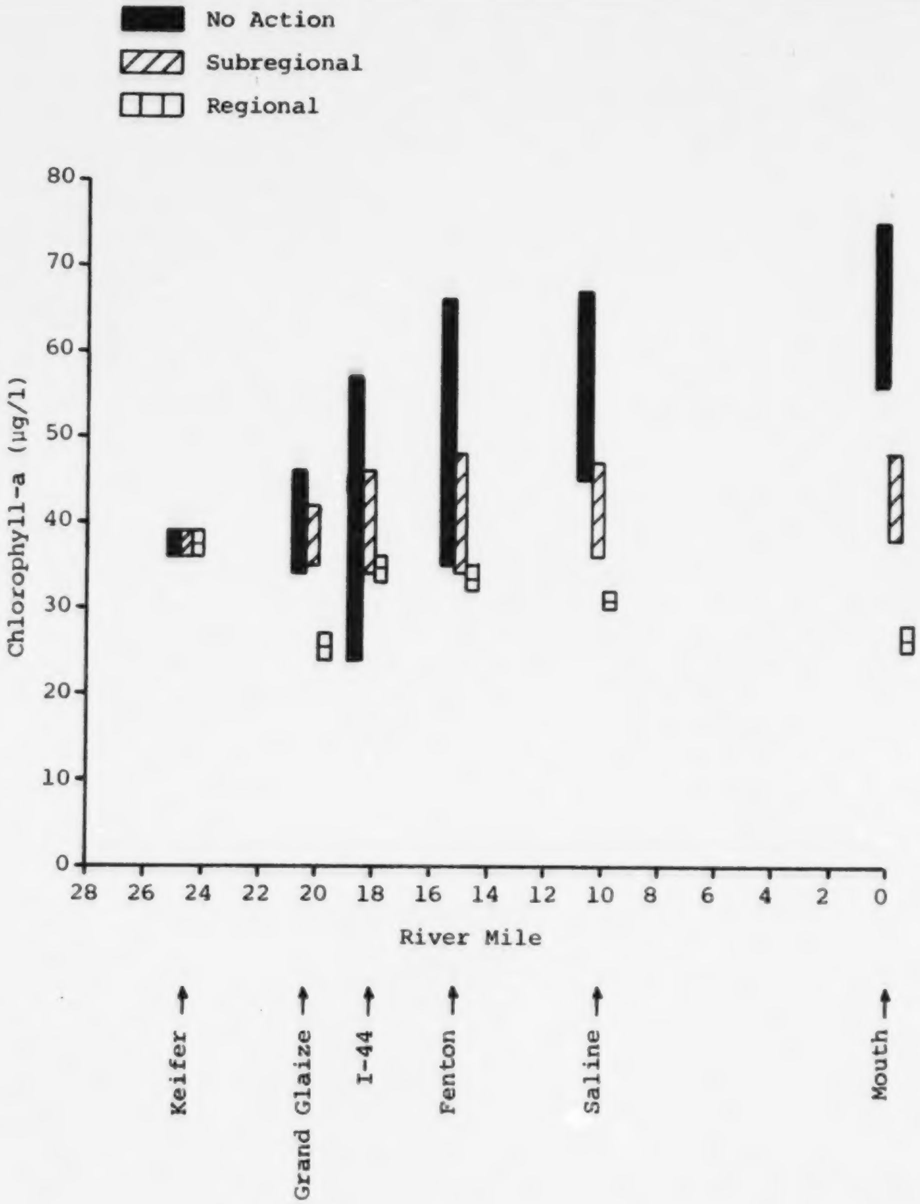

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FIGURE 54

CHLOROPHYLL-A VARIATIONS
JULY 18, 1973

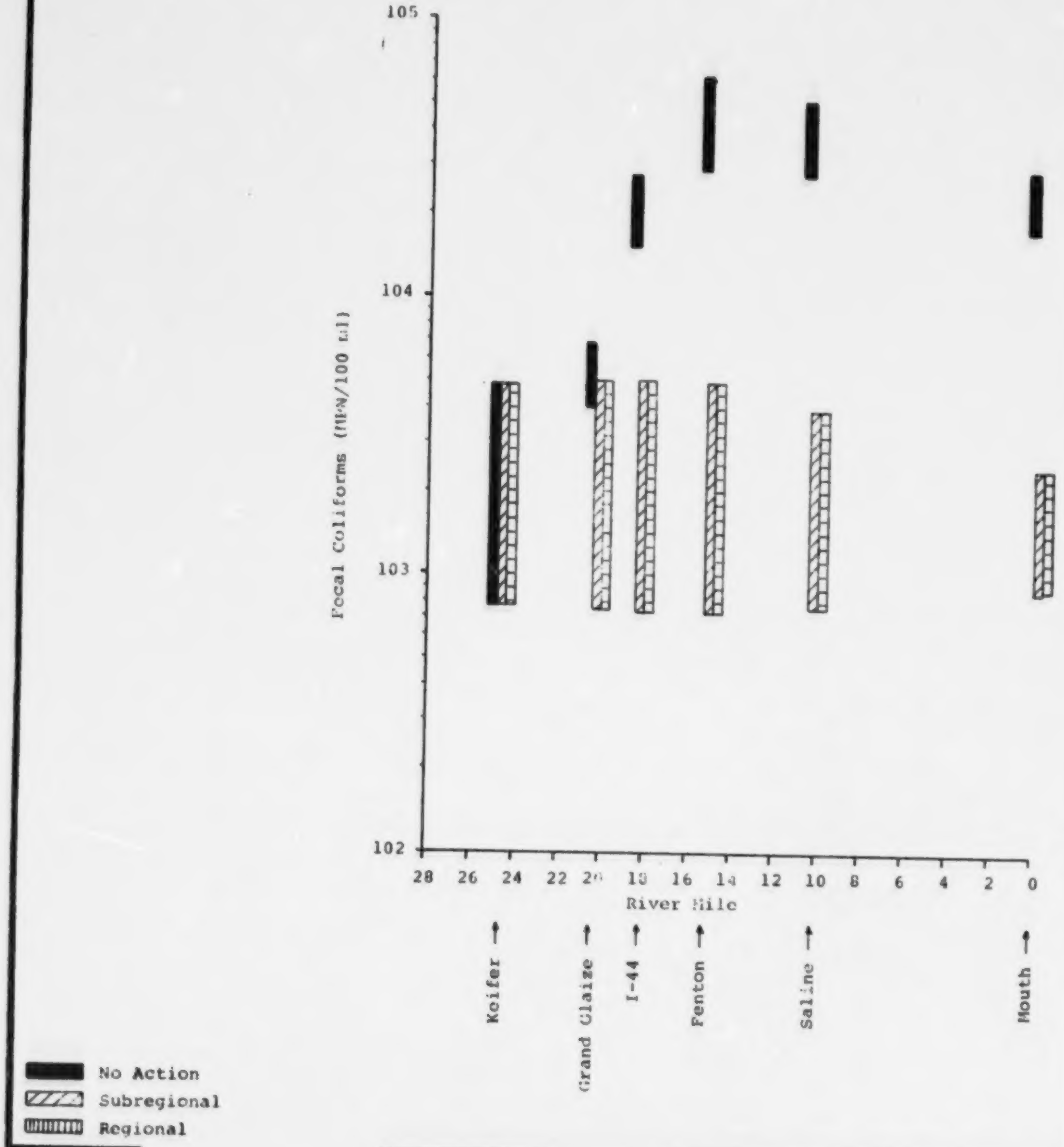

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FIGURE 55

FECAL COLIFORM VARIATIONS
WET WEATHER CONDITIONS
JULY 24, 1973

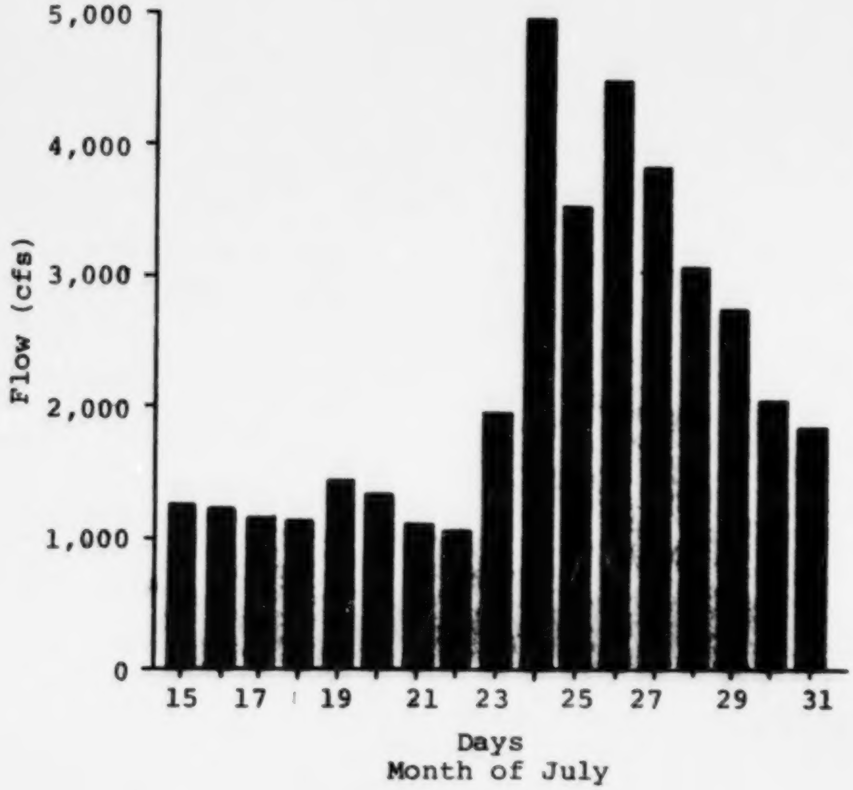

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FIGURE 56

IMPACT OF A RAINFALL EVENT
FLOW

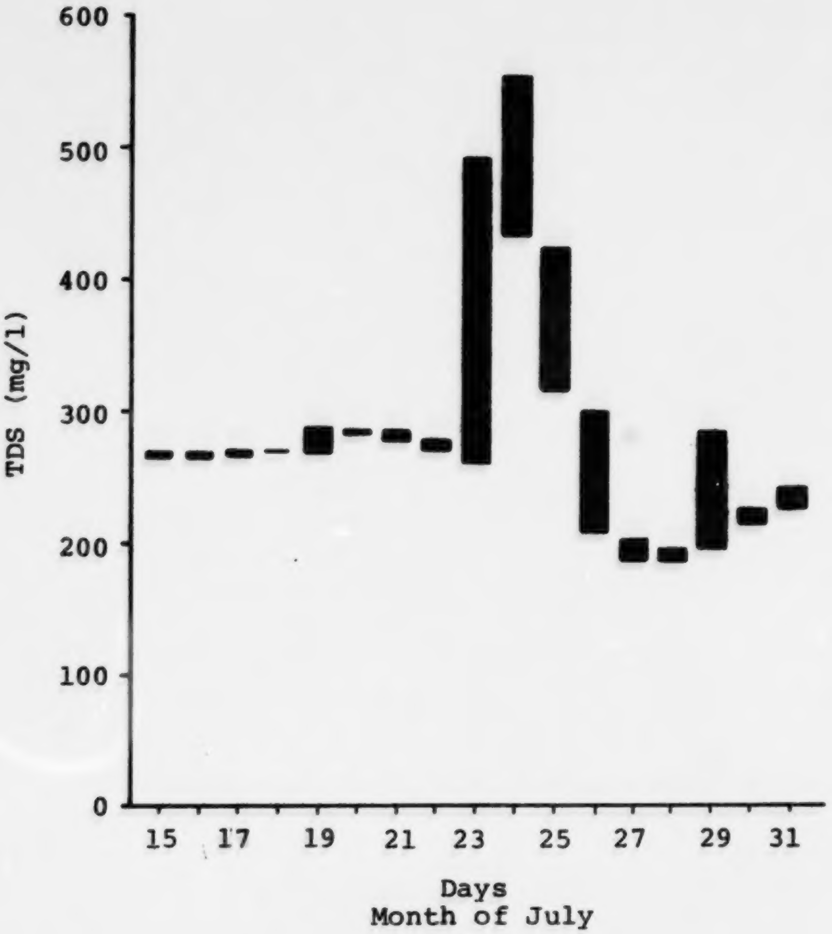

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FIGURE 57

IMPACT OF A RAINFALL EVENT
TDS

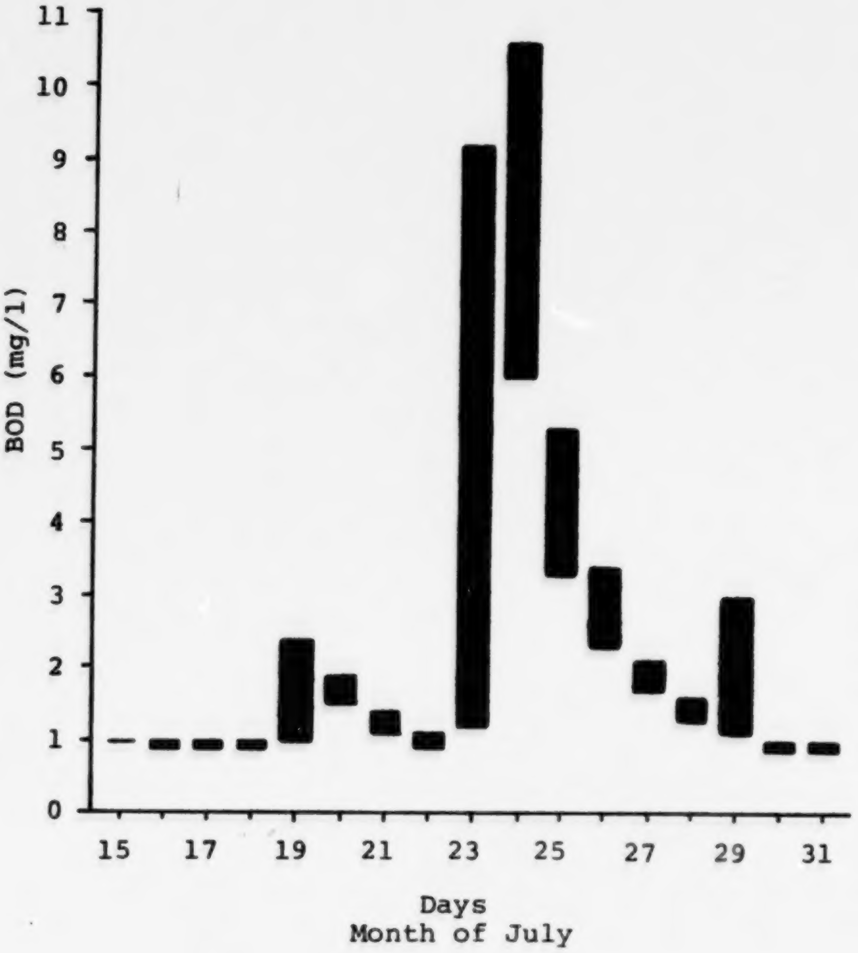

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FIGURE 58

IMPACT OF A RAINFALL EVENT
BOD

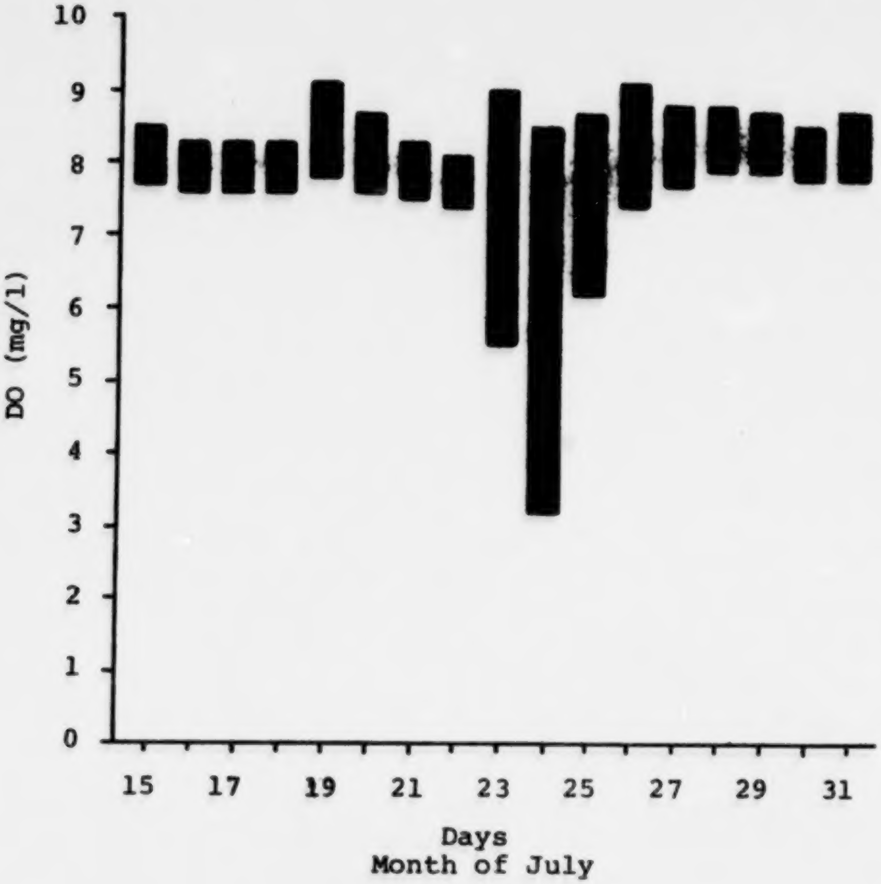

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FIGURE 59

IMPACT OF A RAINFALL EVENT
DO

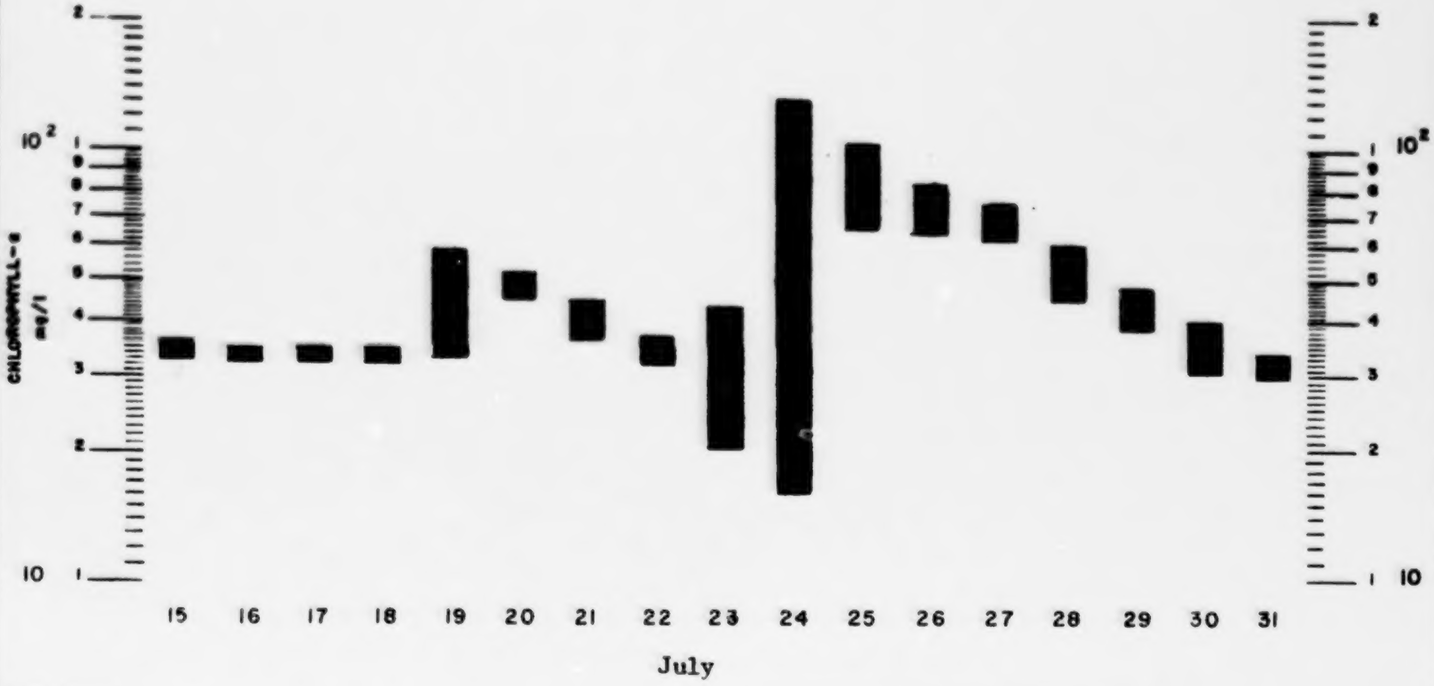

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FIGURE 60

IMPACTS OF A RAINFALL EVENT
CHLOROPHYLL - A

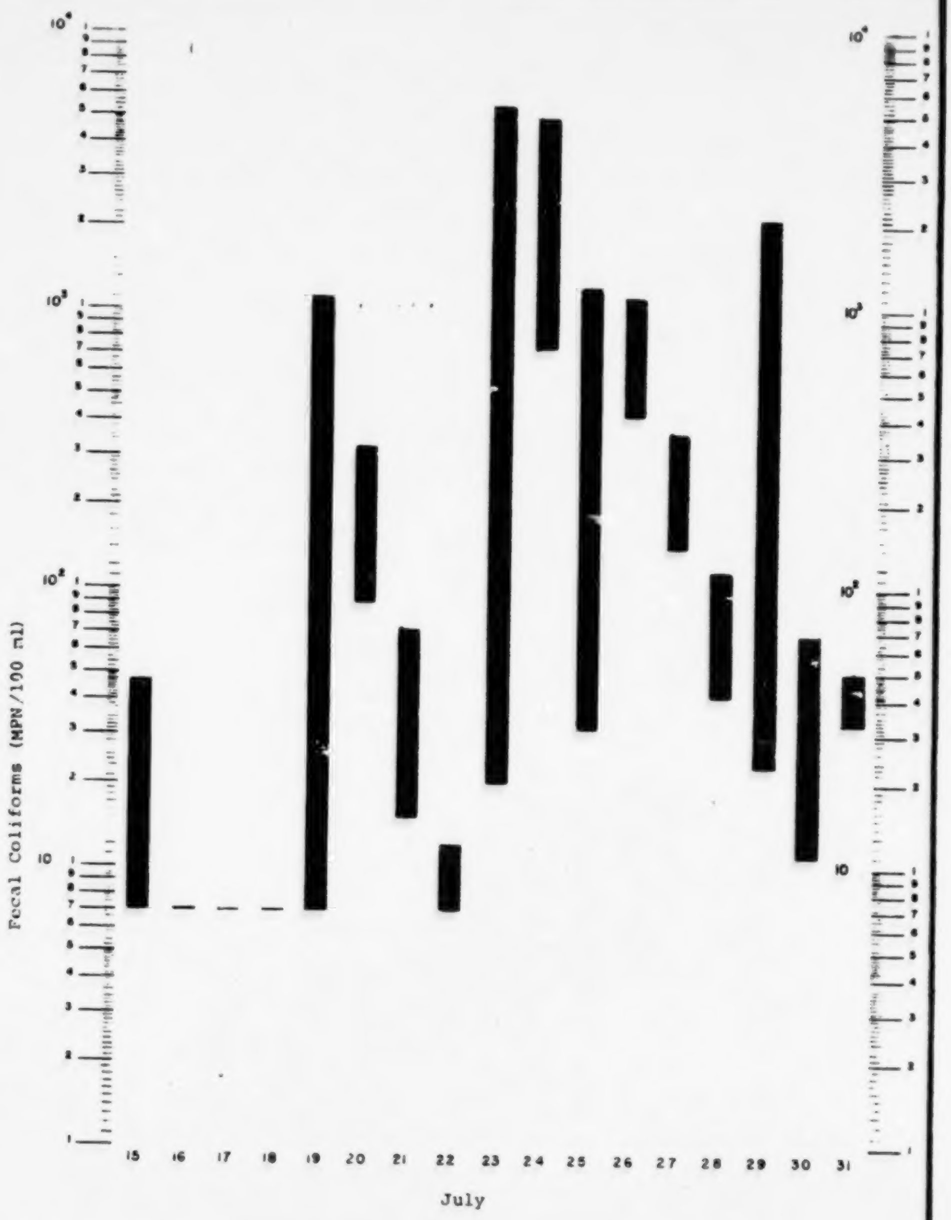

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FIGURE 61

IMPACTS OF A RAINFALL EVENT
FECAL COLIFORM

Temperature simulations reveal no differences between the three alternatives. Temperatures were slightly higher on July 24 than on July 18. At the upstream end, the temperature was predicted to range from 28.0 to 29.0°C during the diel cycle on July 24. Temperatures at Fenton ranged from 28.5 to 29.4°C, increasing to 29.0 to 30.3°C at the mouth.

Similarly, no differences in total dissolved solids were predicted to result from the three alternatives. TDS was predicted to be greater on July 24, following the rain, than on July 18. In general, TDS was constant along the Lower Meramec, ranging from about 420 to 560 mg/l over the diel cycle on July 24.

Figure 62 presents predictions of BOD on July 24. BOD levels are relatively high and exhibit significant variation over the diel cycle. No significant differences result from the three alternatives. It was concluded that the majority of organic loading originated from non-point sources, primarily upstream from the 201 study area.

Dissolved oxygen (DO) predictions are shown in Figure 63. Again, no significant differences are predicted to result from the three alternatives. DO was predicted to vary widely during the day. DO is expected to remain below the state standard of 5 mg/l at all points except near the mouth.

Under the no action alternative, the amount of ammonia present as N is predicted to be less than 0.15 mg/l upstream, increasing slightly as the water flows toward Fenton and then decreasing to less than 0.10 mg/l at the mouth. Ammonia levels under both treatment alternatives were about equal and were only slightly less than under the no action alternative. Neither the existing nor proposed state standard for un-ionized ammonia should be exceeded during wet weather conditions.

The three alternatives resulted in nearly identical nitrate levels in the Meramec River. Maximum nitrate concentrations, as nitrogen, were predicted to range from 1.5 to 1.7 mg/l from Keifer Creek to Saline Creek, decreasing to about 1.0 mg/l at the mouth. The nitrate concentrations at the mouth are significantly greater than predicted for the dry weather conditions.

Figure 64 presents the results of the wet weather simulations for phosphate. The two treatment alternatives result in nearly identical phosphate concentrations, which are only slightly less than for the no action alternative.

Results of the chlorophyll-a simulation are shown in Figure 65. Again, all three alternatives result in nearly the same concentrations of this material.

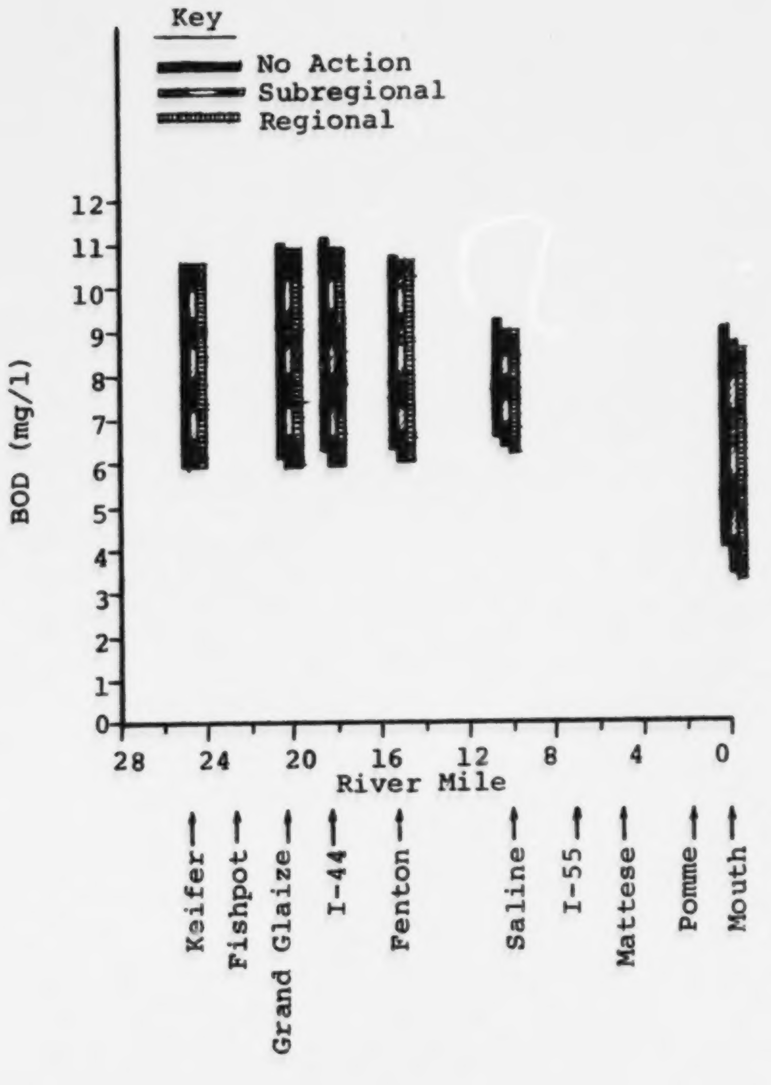

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FIGURE 62

BOD VARIATION
WET WEATHER CONDITIONS
JULY 24, 1973

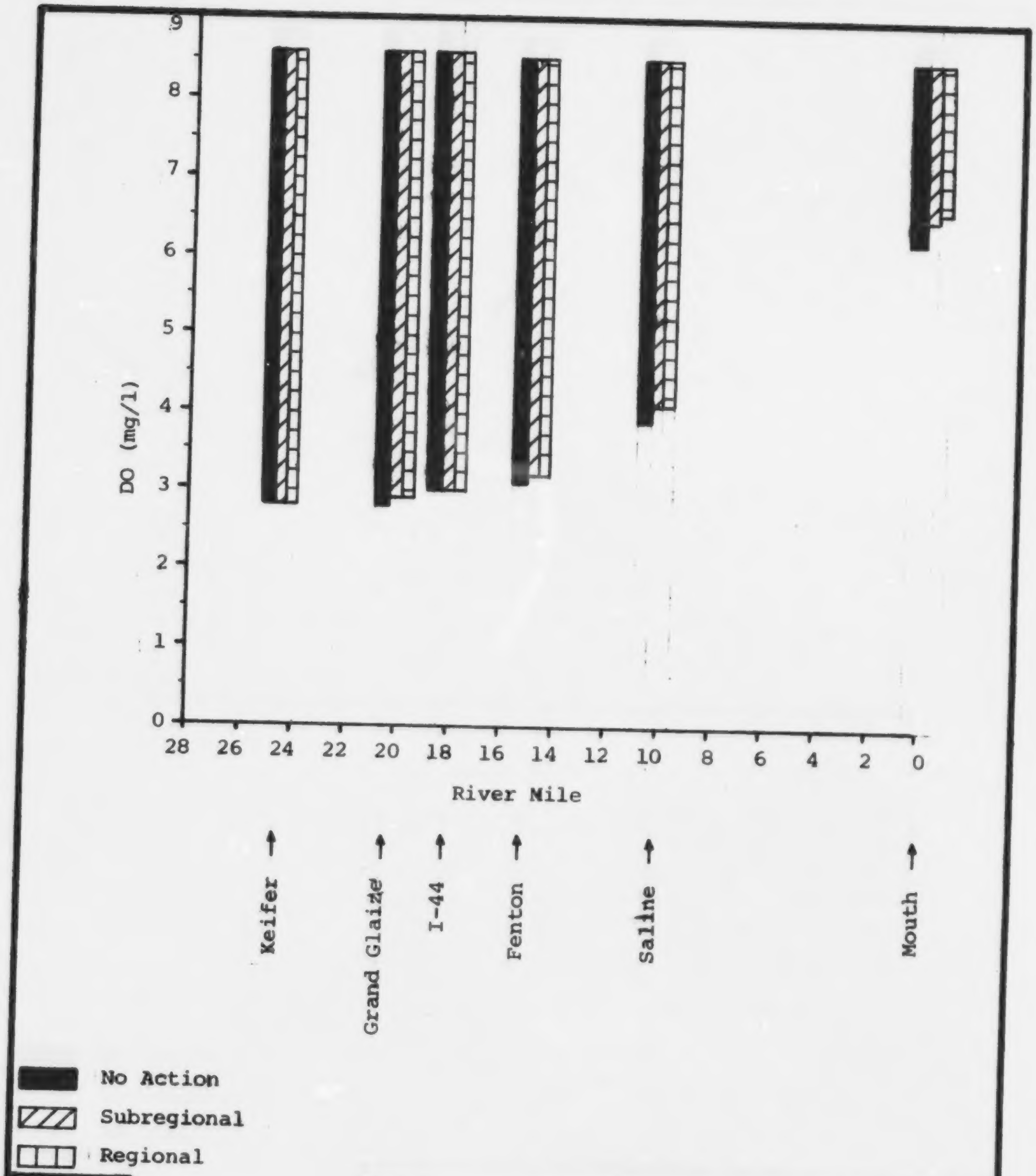

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FIGURE 63

DO VARIATIONS
WET WEATHER CONDITIONS
JULY 24, 1973

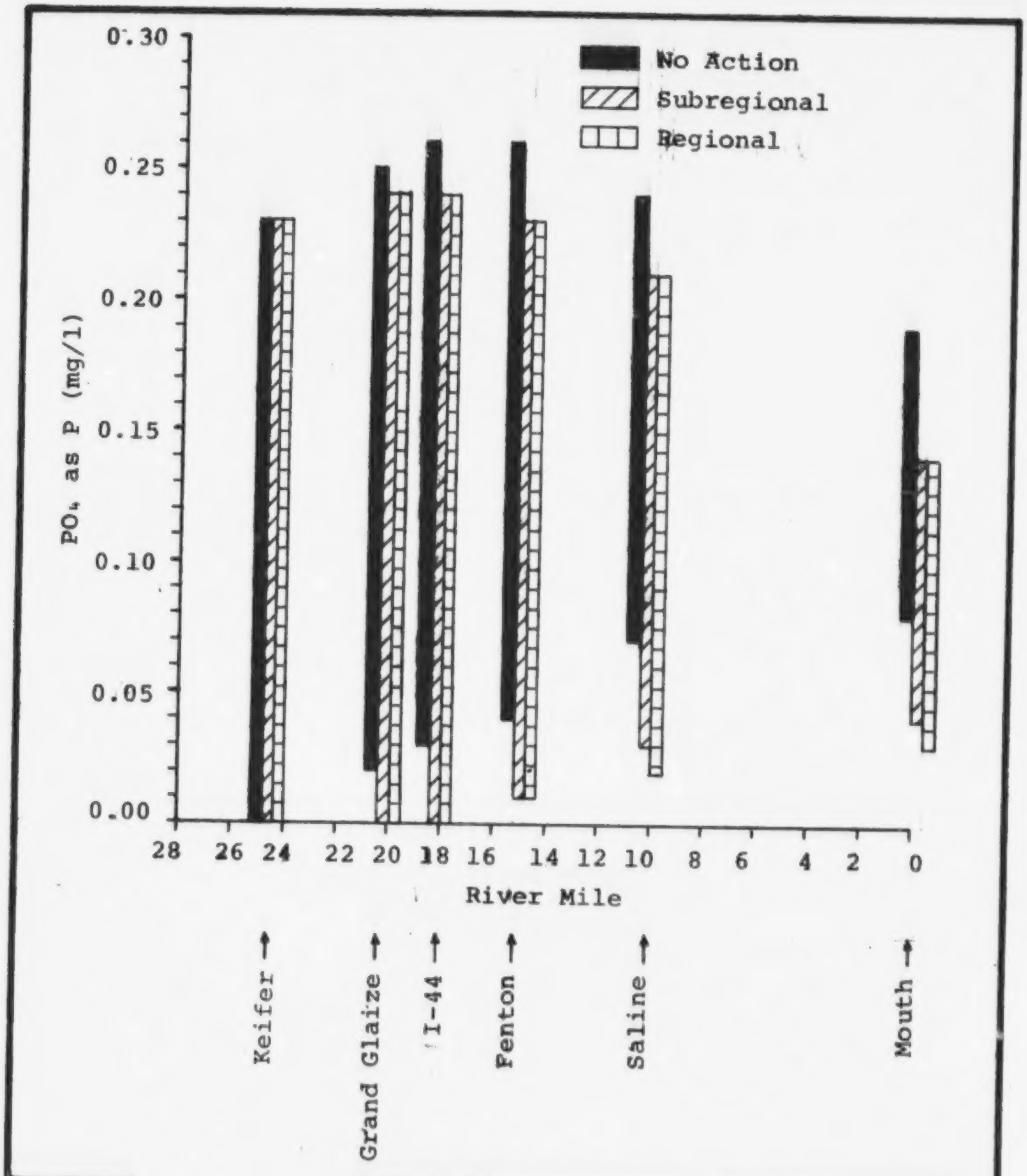

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FIGURE 64

PO_4 VARIATIONS
WET WEATHER CONDITIONS
JULY 24, 1973

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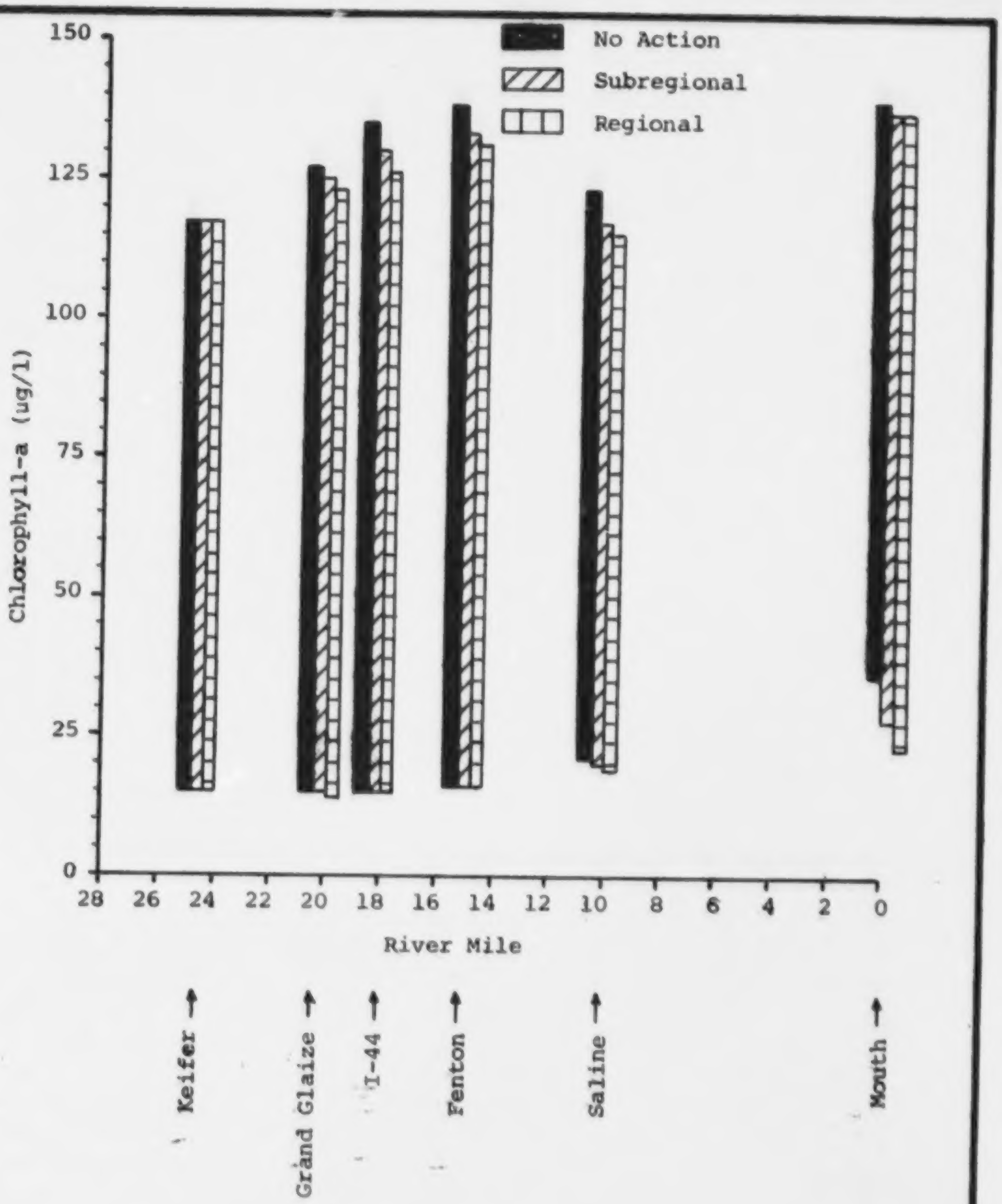

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FIGURE 65

CHLOROPHYLL-A VARIATIONS
WET WEATHER CONDITIONS
JULY 24, 1973

Residual chlorine levels in the Lower Meramec may be as high as 0.3 mg/l if the subregional alternative is implemented. No chlorine will be added to the river under the no action or regional alternatives.

Extreme Low Flow

The water quality model was applied to a period when flow in the Lower Meramec approximated 7-day, 10-year low flow conditions. The 7-day, 10-year low flow was estimated as 280 cfs at Eureka. The simulated flows ranged from 280 cfs at Eureka, to 274 cfs at Fenton, to 304 cfs at the confluence with the Mississippi.

Fecal coliform counts were predicted to be less than 10 MPN/100 ml upstream from Keifer Creek. Fecal coliforms remained less than 10 MPN/100 ml for the regional alternative. Counts of 10 to 20 were predicted for the subregional alternative. The no action alternative will produce coliform concentrations on the order of 130,000 at Fenton, increasing to 150,000 at the mouth.

Temperatures were predicted to be very similar to those predicted for normal low flow conditions (July 18, 1973). Temperatures varied from about 26 to 28°C at the upstream reach to about 27 to 31°C at the mouth. No significant differences were predicted between the alternatives.

TDS also was predicted to remain constant for the three alternatives. TDS ranged from about 230 mg/l to 245 mg/l along the Lower Meramec. These values are somewhat less than the TDS levels predicted for normal summer low flow conditions (see Figure 48).

BOD was predicted to be about 1.3 mg/l at the upstream end of the river. BOD will decrease to values of about 0.8 mg/l at the mouth under the regional alternative. Under the subregional alternative, BOD will increase to 2.0 to 3.0 mg/l in the Lower Meramec. The no action alternative will result in BOD's on the order of 4.0 to 5.0 mg/l.

Dissolved oxygen was predicted to vary from 7.4 to 8.7 mg/l upstream of Keifer Creek. Both the regional and subregional alternatives resulted in similar DO ranges along the Lower Meramec. The no action alternative reduced minimum daily DO slightly, but never below 6.0 mg/l.

Ammonia was predicted to be less than 0.02 mg/l as N above Keifer Creek. Ammonia remained at these low levels under the regional alternative. Ammonia increased somewhat under the subregional alternative, but never exceeded 0.07 mg/l. These levels should not pose toxicity problems. Ammonia was predicted to increase sharply under the no action alternative. Levels of N were predicted to be as high as 0.4 mg/l. These levels may pose toxicity problems in light of the proposed standard of 0.02 mg/l as N of un-ionized ammonia.

Nitrate concentrations were predicted to be less than 0.05 mg/l as N at Keifer Creek. This level was maintained for the regional alternative. Maximum values predicted for the subregional alternative were about 0.9 mg/l. The no action alternative yielded nitrate concentrations that reached a maximum of about 0.7 mg/l.

Upstream phosphate levels were about 0.06 mg/l as P. This level was maintained throughout the Lower Meramec, under the regional alternative. Phosphate increased to as much as 0.1 mg/l under the subregional alternative. Phosphate concentrations in the order of 0.6 to 0.7 mg/l resulted from the no action alternative.

Chlorophyll-a concentrations of about 50 μg/l were predicted upstream from Keifer Creek. Chlorophyll-a would gradually decrease in the downstream direction under the regional alternative, reaching values of about 20 μg/l at the mouth. Diel variations of about 50 μg/l were predicted for the subregional alternative. If the subregional alternative is implemented, daily maximums of over 100 μg/l could result. Even larger values and ranges could result from the no action alternative. This alternative yielded maximum daily ranges of about 80 μg/l and maximum daily values of over 140 μg/l at Fenton.

Residual chlorine will be increased in the Lower Meramec by less than 0.01 mg/l if the subregional alternative is implemented. The regional and no action alternatives would not contribute chlorine to the Meramec.

Tributary Streams

At the present time, the most severe water quality problems in the study area occur in many of the smaller streams tributary to the Lower Meramec River. The no action alternative will result in a decrease of water quality in the tributaries through the year 2000. These streams will be characterized by high concentrations of BOD (often greater than 20 mg/l), ammonia (5 to 10 mg/l as N), nitrate (2 to 3 mg/l as N), and fecal coliforms (over 400,000 MPN/100 ml). Dissolved oxygen levels less than the state standard of 5 mg/l will be common with values less than 3.0 mg/l occurring occasionally.

The impacts of both the regional and subregional alternatives on water quality in the tributaries will be identical, since all wastewater discharges to the streams will be eliminated.

Impacts will vary from one stream to another due to differences in the relative significance of point sources to non-point sources. In general, the following significant improvements will result during dry weather conditions:

1) BOD will be reduced to below 1.0 mg/l.

2) DO will meet the state standard; values approaching saturation will be common

3) Ammonia will be reduced to less than 0.1 mg/l as N

4) Nitrate will be reduced to less than 1.0 mg/l

5) Phosphate will be reduced to less than 0.1 mg/l as P

6) Fecal coliforms will be reduced to less than 500 MPN/100 ml

Temperature, chlorophyll-a, and total dissolved solids will not change significantly with either of the three alternatives.

During rainfall events, water quality in the streams will be somewhat degraded under the two treatment alternatives. However, the treatment alternatives will result in significantly better water quality than will result with the no action alternative.

Mississippi River

Another consideration is the impact of the various alternatives on the Mississippi River. The three alternatives should have no significant impact on dissolved oxygen, TDS, or temperature since the concentrations in the Meramec and in the regional treatment facility effluent will be very similar to background in the Mississippi.

The impacts upon other water quality indicators were evaluated by assuming conservative materials and assigning a mixing zone of one percent of the Mississippi River flow. Low flow conditions on July 18, 1973 were used. It was further assumed that the Mississippi River background level for all constituents was zero.

BOD in the Mississippi River mixing zone would increase by about 1.0 mg/l under both the regional and no action alternatives. Under the subregional alternative, BOD would increase by about 0.6 mg/l. Even an additional 1.0 mg/l of oxygen demand would not adversely effect the oxygen resources of the river.

Ammonia increases of approximately 0.02 mg/l, 0.01 mg/l, and 0.4 mg/l as N could result from the no action, subregional, and regional alternatives, respectively. Nitrate concentrations would increase by less than 0.05 mg/l as N under the no action and regional alternatives and by about 0.15 mg/l as N under the subregional alternative. All three alternatives would increase phosphate by less than 0.1 mg/l as P.

The no action alternative would increase fecal coliform counts by over 25,000 MPN/100 ml. The regional and subregional alternatives would yield increases of less than 10 MPN/ 100 ml.

The no action alternative would not contribute residual chlorine to the Mississippi. Both the subregional and regional alternatives would increase residual chlorine by about 0.06 mg/l. This assumes that chlorine is conservative and, hence, all chlorine in the effluents from the subregional plants finds its way into the Mississippi. In reality, some of this chlorine will be volatilized or reacted, prior to reaching the Mississippi.

It should be noted that the above estimates assume that the mixing zone includes only one percent of the Mississippi River flow.

Conclusions

Normal Summer Low Flow - The no action alternative will result in increased degradation of water quality in the Lower Meramec. This impact will be most pronounced in terms of significant increases in fecal coliforms and increased organic loadings (BOD). All three alternatives will have no significant impact on temperature, dissolved oxygen, TDS, or ammonia. Both treatment alternatives (subregional and regional) will result in somewhat improved water quality with regard to coliforms, phosphate, and algae. The subregional alternative will result in increased nitrate concentrations since nitrification will be conducted at the treatment facilities. The subregional alternative will also raise the level of residual chlorine in the Meramec.

Extreme Low Flow - During extreme low flow conditions, the no action alternative will result in very poor water quality, particularly in terms of fecal coliforms. BOD, ammonia, nitrate, phosphate, and chlorophyll-a levels will be relatively high. Temperature, TDS, and DO will be relatively uniform among the three alternatives. The removal of wastewater discharges, as part of the regional alternative, will result in the greatest improvement in water quality under these conditions. The subregional alternative represents an improvement over the no action alternative, but is not as favorable as the regional concept. The subregional alternative will result in significant increases in chlorine and nitrates.

Rainfall Event - The effect of the July 24, 1973 rainfall event was evaluated. Marked decreases in water quality were observed in the Lower Meramec on this day, as compared to July 18, 1973 which followed a dry period. Fecal coliforms, BOD, TDS, and nutrients were higher than they were under dry weather conditions. Minimum daily dissolved oxygen was reduced during the rainfall event. For most parameters, impacts will be nearly the same for all three alternatives. The no action alternative will result in significantly higher fecal coliform counts than with the two treatment alternatives. However, coliform counts of 1000 to 2000 MPN/100 ml could result from the two treatment alternatives. The subregional alternative may somewhat elevate residual chlorine concentrations in the river. It was concluded that non-point sources become the most significant sources of decreased water quality during rainfall events.

Tributary Streams - The no action alternative will result in continued degradation of water quality in the small streams tributary to the Lower Meramec. High concentrations of BOD, ammonia, nitrate, and fecal coliforms will continue. In addition, low dissolved oxygen levels will be observed. Both the subregional and regional alternatives will result in significant improvements in water quality in these streams as wastewater discharges are eliminated. The differences between the no action alternative and the treatment alternatives became less significant during rainfall events due to non-point loads.

Mississippi River - Impacts on water quality in the mixing zone of the Mississippi River will be relatively minor. In fact, no impacts upon dissolved oxygen, TDS, or temperature are anticipated. The no action alternative presents the most severe adverse impacts on BOD and fecal coliforms. The regional alternative provides the most severe increase in ammonia. The subregional alternative results in the most severe impacts on nitrate and residual chlorine. However, the impacts on the Mississippi River were judged to be relatively minor for all alternatives, particularly as the discharge for the Meramec is mixed across the entire cross-section of the Mississippi River.

Final Comment - The no action alternative offers little promise for improving water quality in the Lower Meramec study area. This alternative will likely result in further degradation of water quality in the tributary streams and in the Meramec River itself. Both the subregional and regional alternatives would result in significant improvements in water quality in the tributary streams. During dry weather conditions, both treatment alternatives would result in improved water quality in the Meramec River. During wet weather conditions, the treatment alternatives do not result in significant improvements over the no action alternative due to the impacts of non-point pollution sources. The impacts of all three alternatives on the Mississippi River are anticipated to be relatively minor.

IMPACTS ON GEOLOGY AND GROUNDWATER

No Action Alternative

This alternative would have no impact on the geology of the study area. However, it would have two major types of impacts on the groundwater. If wastewater treatment continues to be inadequate, those portions of the tributary creeks that are losing streams will continue to pollute the upper aquifers. As the population of these areas increases, the degree of pollution will tend to increase. The second type of impact stems from the fact that the present collection and treatment systems are already overloaded. As a result, new home builders may install individual treatment systems. As has been previously mentioned, the soils and geological setting of the study area is such that an increased use of septic tank systems would, most likely, result in an increased pollution of the upper aquifers.

Subregional Alternative

The continued groundwater pollution mentioned above will be abated by this alternative. The only other impacts that this alternative will have on the geology or groundwater of the study area will be the disturbance of the soils where new collector sewers are constructed and, possibly, the temporary lowering of high water tables adjacent to these new sewer lines during construction. Both of these impacts would be temporary and minor.

Regional Alternative

This alternative will have the same impacts as the subregional alternative. In addition, the construction of the main trunk line and connecting spurs will also impact on the geology and groundwater of the study area. The two potential methods of construction, open cut and tunneling in bedrock, would each have a separate set of impacts and are, therefore, discussed separately.

Open Cut Method - The detailed methods that would be used to construct the trunk sewer and connecting spurs under this general methodology have not yet been specified because of the tremendous variability of soil types and groundwater levels.

Several possible methods which could be used under various combinations of soil types and groundwater levels have been identified.

Where relatively fine grained soil types are encountered and no appreciable groundwater seepage occurs, the cross-sectional profile of the open cut will probably be similar to that shown in Figure 66. Where significant groundwater seepage does occur in fine grained soils, the same basic profile will probably be used; however, a series of wellpoints will be added to draw the water table down to a point below the line of seepage. Horner and Shifrin (110) have estimated that two-thirds of the proposed route (see Figure 67) will be constructed in relatively fine grained soils. If the general profile shown in Figure 66 is used for two-thirds of the route, roughly 800,000 to 1,000,000 cubic yards of soil will have to be excavated and replaced for this portion of the main trunk line.

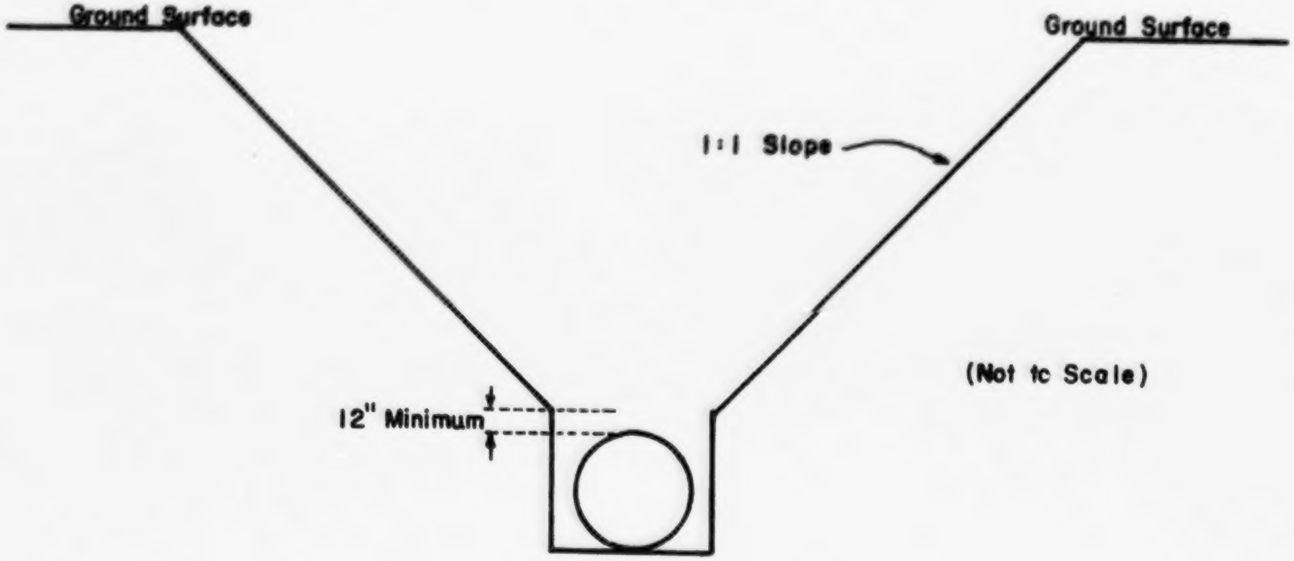
Although the sewer pipe will take up some of the volume of the area excavated, this will probably be only a relatively small amount of space and, in most cases, the soil displaced by the pipe could be redistributed over the area of excavation (111). If the profile in Figure 66 is used for two-thirds of the route shown in Figure 32, a minimum surface excavation area of 50 acres would result during construction of this portion of the main trunk line.

In areas where the open cut method of construction is used in coarse grained soils (sand and gravel), a slightly different approach will have to be taken. In areas where the water table is low, a profile similar to that shown in Figure 66 could be used, with certain modifications. The coarser soil probably could not be safely maintained at a 1:1 slope. Side slopes as gentle as 3:1 or 4:1 (horizontal:vertical) might be necessary. Heavy sheeting and bracing will probably be necessary for supporting the relatively low sections of vertical walls in the bottom of the trench.

In areas where excavation goes below the water table, the soils will have to be dewatered. In sand and gravel, this would require a system of very closely spaced wellpoints or the injection of cement grout into the soils, or both. It might also require the use of sheeting and bracing so that vertical trench walls could be maintained for nearly the entire depth of the excavation.

When sewer lines must cross the river (see Figure 32), a different type of trench will be required. A dragline typically would have to be used to excavate a 3 foot wide trench through the sediment. The side slopes of the trench would be as steep as possible; probably 1:1. The trench would reach at least 6 feet into the sediment or it would be excavated to bedrock.

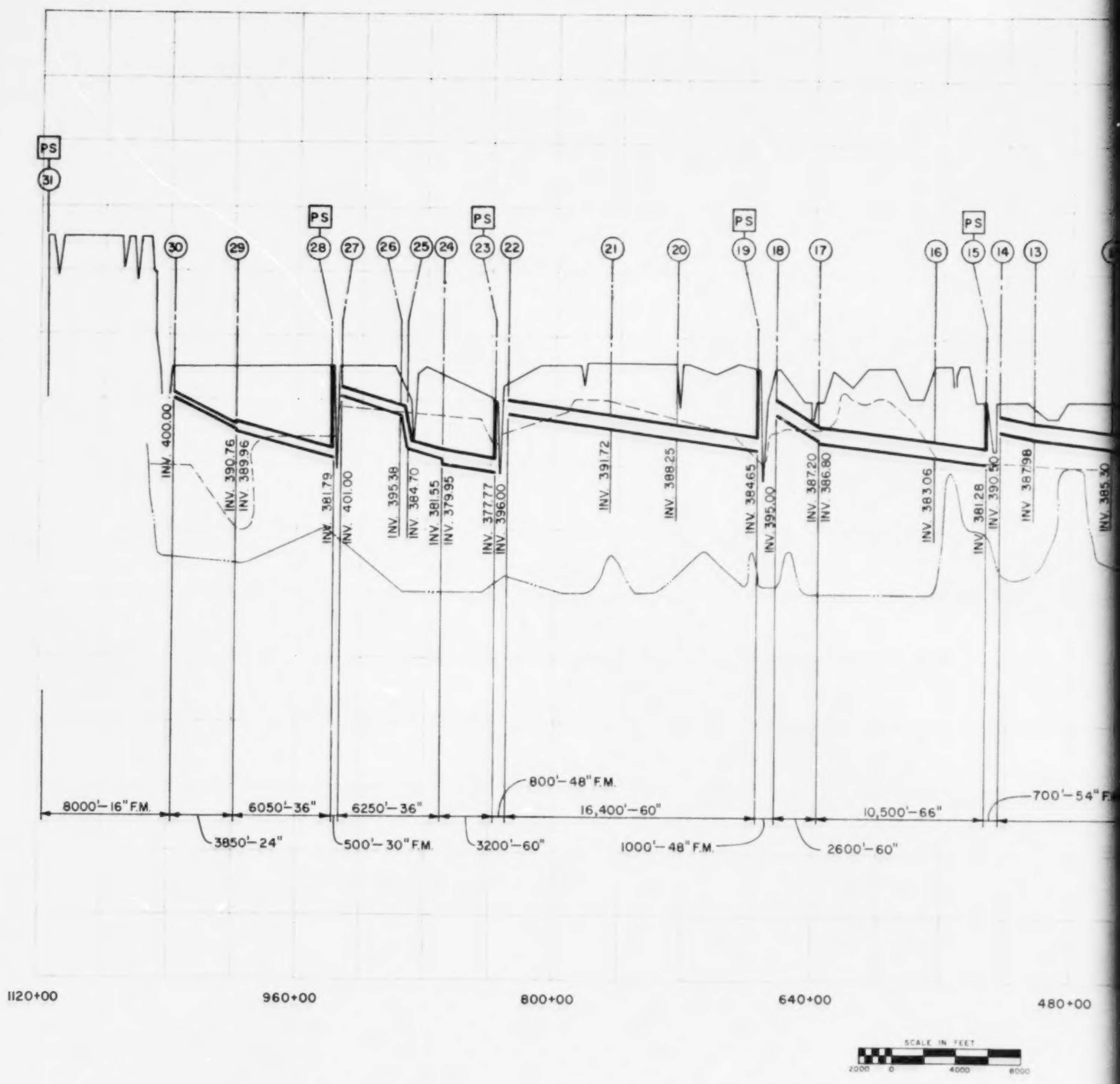
62<


Ground Surface
Ground Surface
1:1 Slope
(Not tc Scale)
12" Minimum

RETA
R806

FIGURE 66

TYPICAL TRENCH CROSS SECTION:
OPEN CUT ALTERNATIVE


PS
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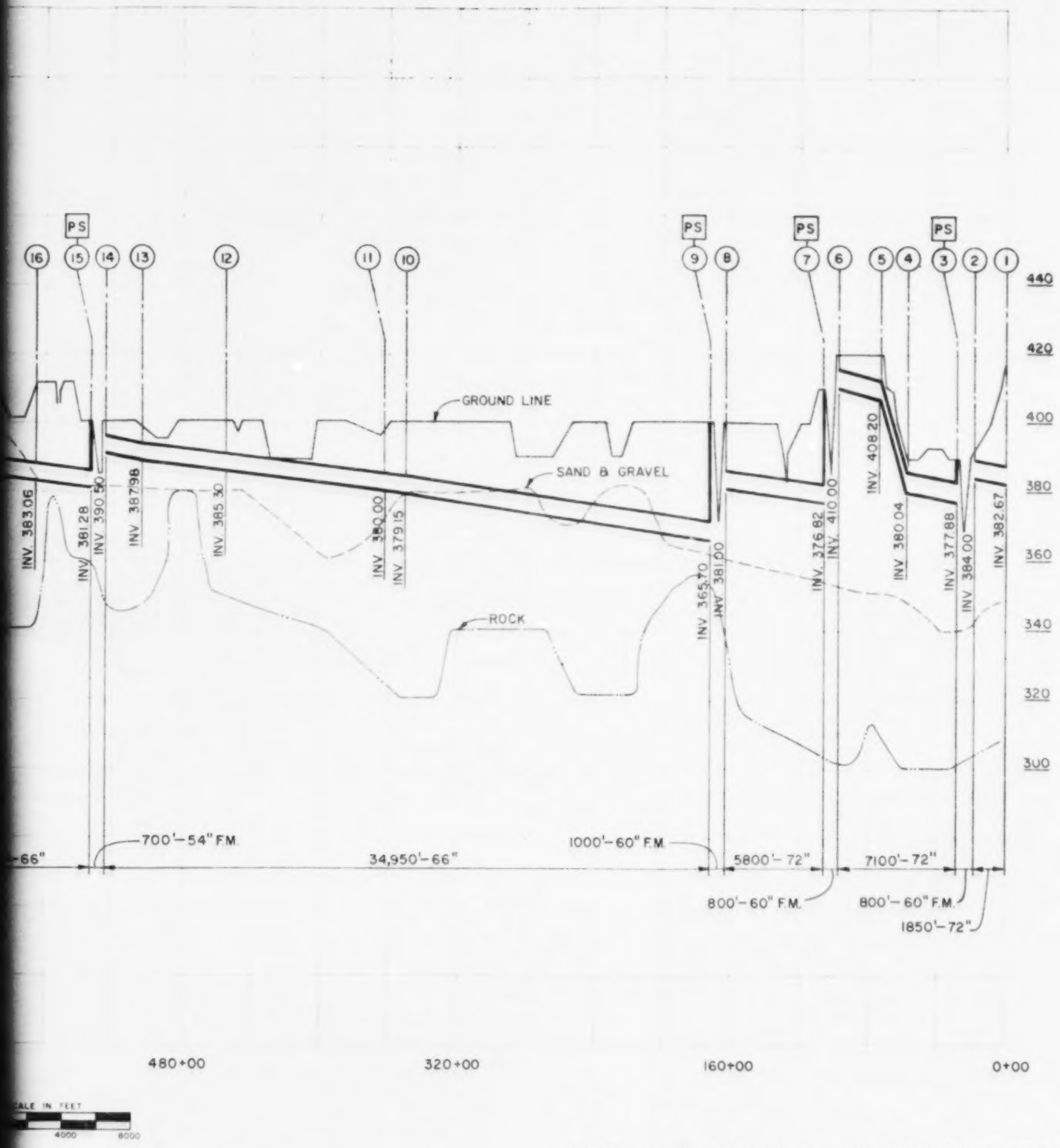
13
INV. 400.00
INV. 390.76
INV. 389.96
INV. 381.79
INV. 401.00
INV. 395.38
INV. 384.70
INV. 381.55
INV. 379.95
INV. 377.77
INV. 396.00
INV. 391.72
INV. 388.25
INV. 384.65
INV. 395.00
INV. 387.20
INV. 386.80
INV. 383.06
INV. 381.28
INV. 390.50
INV. 387.98
INV. 385.30
8000'–16" F.M.
3850'–24"
6050'–36"
500'–30" F.M.
6250'–36"
3200'–60"
800'–48" F.M.
16,400'–60"
1000'–48" F.M.
2600'–60"
10,500'–66"
700'–54" F.M.
1120+00
960+00
800+00
640+00
480+00
SCALE IN FEET
2000
0
4000
8000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1
440
420
400
380
360
340
320
300
GROUND LINE
SAND & GRAVEL
ROCK
INV 383.06
INV 381.28
INV 390.50
INV 387.98
INV 385.30
INV 380.00
INV 379.15
INV 365.70
INV 381.00
INV 376.82
INV 410.00
INV 408.20
INV 380.04
INV 377.88
INV 384.00
INV 382.67
-66"
700'-54" F.M.
34,950'-66"
1000'-60" F.M.
5800'-72"
7100'-72"
800'-60" F.M.
800'-60" F.M.
1850'-72"
480+00
320+00
160+00
0+00
ALE IN FEET
4000
8000

METROPOLITAN ST. LOUIS SEWER DISTRICT
LOWER MERAMEC RIVER BASIN
201 FACILITY PLAN
CONVEYANCE SEWER PROFILE
ALTERNATE NO. 1-OPEN CUT METHOD

Excavation to bedrock would be preferable so that the pipe could be anchored into the rock. If the bedrock is overlaid by more than about 10 feet of sediment, it probably will not be feasible to excavate to bedrock.

It will be necessary to either anchor the sewer to the bedrock or bury it below the level where the sediments might be disturbed. The minimum depth of burial in sediments depends on several factors, but is estimated (112) to be no deeper than about 6 feet in the project area. Therefore, burying a 5-foot diameter sewer under 6 feet of sediments would disturb a path at least 25 feet wide along the line of the crossing. An area on the banks would be required for temporarily storing the excavated sediments while the pipe is being laid. If turbid return water from the sediment stockpile proves to be a problem, this water will be diverted into a settling basin before being discharged back into the Meramec River.

In areas where ground surface disturbance is costly or effects environmentally sensitive areas (e.g., street crossings or important archaeological sites), an alternative trenching method could be employed. Instead of sloping the walls of the trench as shown in Figure 66, sheeting and bracing could be used to maintain vertical walls all the way to the ground surface. This would minimize the area disturbed. This method of construction is very expensive and would be utilized only when absolutely necessary.

Certain impacts will occur regardless of the specific construction methods chosen and the portions of the project where each would be utilized. One of the primary impacts will be the disturbance of large quantities of soil and sediments. Whenever soil is disturbed, the hydrologic character of the soil is altered. Adjacent drainageways would experience an increased sediment load from the start of construction until the disturbed area is successfully revegetated. Since most of the trunk line and connecting spurs would be constructed in areas of very low relief, this increased sediment load would probably be minimal and fairly localized. However, at river crossings, especially where fine grained soils are encountered, there will probably be a significant addition to the suspended solids load and increased turbidity of the river. This addition would be especially noticeable locally during low river states. Due to the technical difficulties in laying the pipe and excavating the trench during higher stages, most river crossings would have to be constructed during low river stages.

Two additional major primary impacts involve the dewatering operations, which will probably prove necessary. Under the open cut method of construction, dewatering would occur primarily in alluvial soils rather than bedrock. This dewatering, especially if required as deep as 30 to 35 feet (such as near locations

9, 16, 24 and 28 on Figure 32), could cause some subsidence of the ground surface in adjacent areas. This subsidence could cause nearby rigid structures, such as road pavements and walls, to crack. The greatest subsidence over the most widespread area would occur where thick, relatively fine grained soils overlie a gravel layer that requires dewatering. It is impossible to accurately predict the degree or range of this subsidence without first performing an extensive, site-specific soils investigation. However, it seems unlikely that significant subsidence would occur more than 150 to 200 feet from the dewatering operations.

The other major impact associated with dewatering operations would occur in the Valley Park-Kirkwood area between locations 23 and 27 on Figure 32. As shown in Figure 22, the alluvium in this area contains groundwater with a high chloride content. Therefore, the discharge from dewatering operations in this area would also have a high chloride content. Because of the relative volumes and concentrations involved, if the discharge from the dewatering activities is discharged directly into the Meramec River, it will have a very small, if any, adverse impact. Dewatering will, however, have a significant impact on the surrounding groundwater flow pattern. The line of wellpoints or dewatering mechanisms employed would significantly increase the steepness of the hydraulic gradient in the alluvium, thus increasing the very high chloride content water's rate of flow toward the river. The water quality in this important aquifer would be seriously degraded as a result.

Tunnel Method - This method entails the construction of a tunnel below the level of the Meramec River within the underlying bedrock. The tunnel would be constructed within the Burlington Formation wherever possible. At its far upstream end (locations 21 to 22 on Figure 33), it would probably go through the Fern Glen, Bushberg, Glen Park (if present), and Maquoketa Formations and possibly end in the Kimmswick Formation. Near the lower end (locations 4 to 8 on Figure 33) it might also go through a portion of the Warsaw Formation, if this formation proves suitable for tunneling. If slaking or rock strength proves to be a problem in the Warsaw Formation, the tunnel elevation will be dropped slightly to avoid this formation.

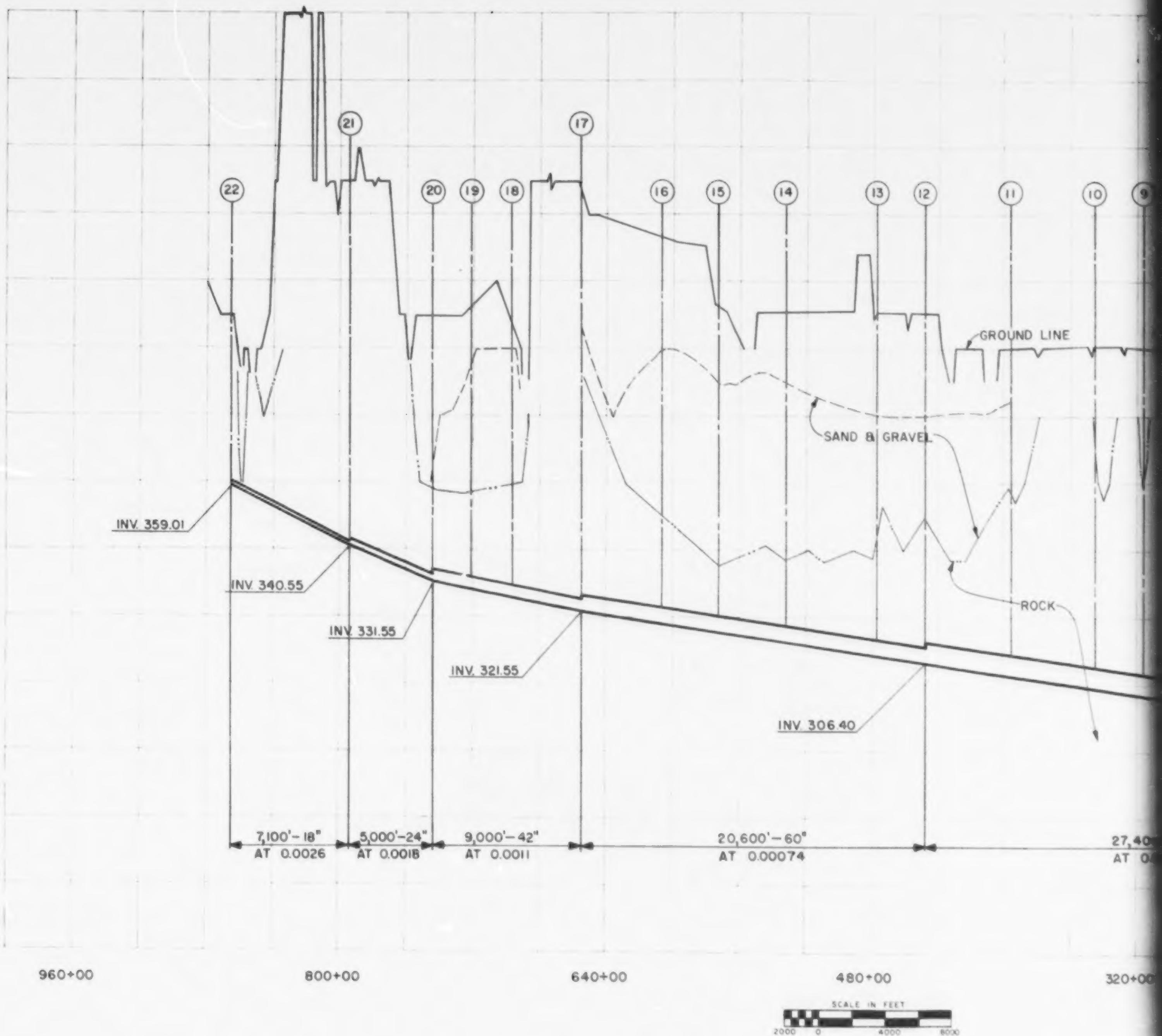
The method of tunnel advancement has not been specified yet, but will involve either drilling and blasting or the use of a continuous rock tunneling machine (mole). A mole will, most likely, be used. If the mole is used, there will be no detectable vibration at the ground surface during tunneling.

The broken rock (muck) produced by the mole during tunneling would be removed at construction shafts. The locations of these shafts are shown on Figures 33 and 68. Once removed, the muck would have to be disposed of. It is anticipated that a total of about 250,000 cubic yards of muck will be generated (167,000 cubic yards of rock in place) during the construction of the trunk line, shafts and connecting spurs shown in Figure 33 (139). It is also anticipated that the muck from the lower end of the tunnel (69,000 cubic yards) could be used as fill during the construction of the treatment plant. The remainder of the muck could be hauled to a quarry and sold as low grade fill material. The precise disposition of the variety of materials to be excavated is not possible to predict at this time. The amounts of material which will be marketable or which might require special considerations for deposition are dependent on more detailed knowledge on the materials characteristics than is presently available. The only assurance that can be given at this time is that all materials will be disposed of in accordance with regulations in effect at the time of their disposal and that all necessary permits and site approvals will be secured.

The smallest mole available will produce a tunnel approximately 4.5 feet in diameter. Since this diameter is much larger than required for the flow rates expected in the upper end of the tunnel, a smaller diameter pipe would be laid in the tunnel in this area. The tunnel would then be filled with concrete to the level of the top of the pipe. The air space above the pipe would then be sealed at each of the construction shafts.

Since the tunnel would be constructed entirely below the present water table, it is expected that groundwater will seep into the tunnel during construction. The rate of seepage has not been estimated, but would vary considerably throughout the length of the tunnel. When the bedrock above the tunnel is relatively thin, such as at locations 3 through 6, 13 through 16 and 18 through 20 on Figure 68, the rate of seepage will probably be higher than in areas where the bedrock cover is quite thick, such as at locations 7 through 11 on Figure 68. However, south of location 11, the Warsaw Formation overlies the tunnel elevations, and the shale units of this formation will probably limit the rate of seepage from above.

Since the tunnel would be constructed primarily in a limestone unit and there is evidence of Karst development in the study area, it is possible that a large, interconnected system of solution channels (submerged cave system) will be encountered during construction of the tunnel. Hopefully, a submerged cave system would be detected by either drilling a test hole in advance of the mole or by intersecting a small branch off the main conduit. If the main conduit of the system were unexpectedly broken into by the mole, the accompanying rush of water into the tunnel could be disastrous. The lack of large springs in the study area indicates that large submerged cave



22
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11
10
9
GROUND LINE
SAND & GRAVEL
ROCK
INV. 359.01
INV. 340.55
INV. 331.55
INV. 321.55
INV. 306.40
7,100'-18"
AT 0.0026
5,000'-24"
AT 0.0018
9,000'-42"
AT 0.0011
20,600'-60"
AT 0.00074
27,40
AT 0
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320+00
SCALE IN FEET
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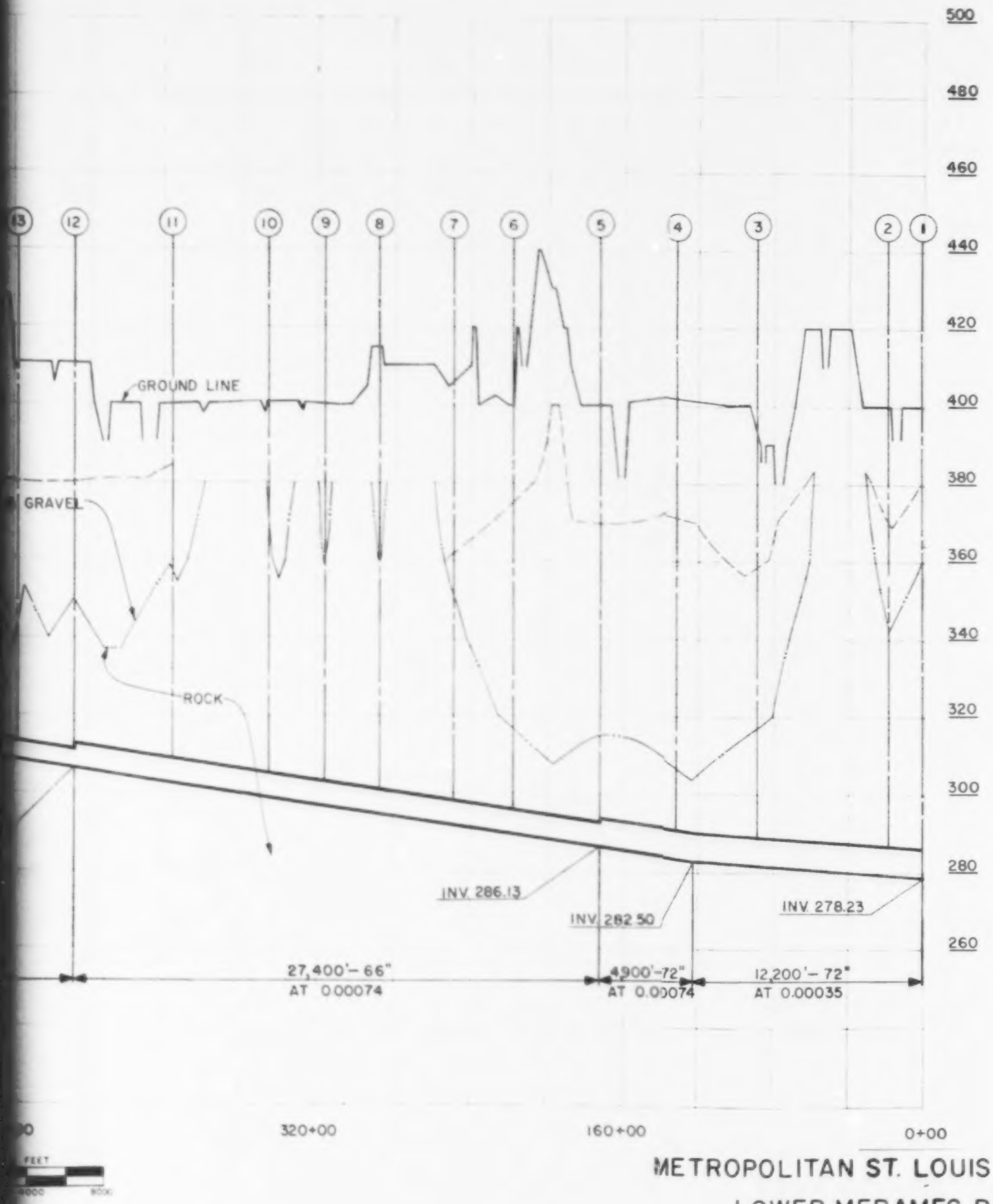
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5
4
3
2
1
GROUND LINE
GRAVEL
ROCK
INV. 286.13
INV. 282.50
INV. 278.23
27,400'– 66"
AT 0.00074
4900'–72"
AT 0.00074
12,200'– 72"
AT 0.00035
320+00
160+00
0+00
FEET
4000
8000

METROPOLITAN ST. LOUIS SEWER DISTRICT
LOWER MERAMEC RIVER BASIN
201 FACILITY PLAN
CONVEYANCE SEWER PROFILE
ALTERNATE NO. 2–TUNNEL METHOD

systems are not common. Therefore, the probability of encountering a large submerged cave system during construction of the tunnel is very slight.

The hydraulic characteristics of the bedrock and soils surrounding the proposed tunnel location have not been studied sufficiently to accurately estimate the anticipated normal seepage rates. However, a crude analogy may be drawn between this tunnel and a similar tunnel proposed for the Metropolitan Sanitary District of Greater Chicago (MSCGC) (113). Much data exists and seepage estimates have been calculated for this tunnel. The estimates made for the MSDGC tunnel were concerned with long-term seepage into an unlined tunnel. The MSDGC tunnel will be constructed in a relatively impermeable dolomite, which is roughly analogous to the Burlington Formation. The measured hydraulic conductivity of the dolomite was roughly 0.24 gallons per day per cubic foot (1.1×10^{-5} cm/sec). The MSDGC tunnel will be much larger than the proposed lower Meramec tunnel (20 to 60 feet in diameter versus 4.5 to 6 feet in diameter, respectively). However, when using well hydraulics analysis, the relative diameters of the tunnels in these ranges has little effect on the relative infiltration rates (114). By using the highest estimated unit infiltration rate for the 10-foot diameter MSDGC tunnel (24.0 gpd/lineal foot), and applying this rate to the proposed Lower Meramec tunnel, the seepage rates shown in Table 51 can be obtained.

TABLE 51

SEEPAGE RATES

Length of Unlined Tunnel Segment (feet)	Estimated Seepage Rate (gpd)	Estimated Seepage Rate (gpm)
100	2,400	1.67
1,000	24,000	16.67
5,000	120,000	83.33
86,200[a]	2,069,000	1,436.67

NOTES: [a] Total Length of trunk line

Since these estimates are based on long-term, equilibrium conditions, the rate expected during construction would be higher. Although how much higher the rate would be is unknown, it is believed that these estimates are within the correct order of magnitude.

The water that seeps into the tunnel during construction would be pumped out at the construction shafts. If the tunnel is constructed entirely within the Burlington Formation, this water will probably be relatively low in suspended solids. If the tunnel is constructed in a more shaly formation, such as the Warsaw or Maquoketa Formation, the seepage water would most likely be quite turbid from suspended solids.

A comparison of Figures 23 and 33 shows that the proposed tunnel route will be in an area where the groundwater is high in chlorides, particularly in the lower portion of the tunnel. Thus, the water that would seep into and, ultimately, be discharged from the tunnel would, most likely, also be high in chlorides. If this water is discharged directly into the Meramec River, its impact will be negligible. However, if this water is discharged into a low flow tributary creek, its impact, depending on the relative flows, might be detectable. Since a chloride ion concentration of 250 to 500 mg/l (the expected maximum range) is generally not considered to be harmful to either aquatic life or humans, the impact of this discharge, even on a low flow creek, would be minimal.

BIOLOGICAL IMPACTS

The project area includes a diversity of biological habitat types which are subject to adverse impacts under one or more of the project alternatives. This section consists of a comparative examination of the extent of those impacts and includes a discussion of impacts related to construction and of impacts related to the increased development which would be accommodated under these plans.

The preparation of detailed, finalized drawings of the specific routes of sewer lines is not a part of this stage of the project planning process. Thus, it is impractical to present an ecological analysis based on populations of individual species or microhabitats in this document. The approach taken in this chapter focuses, therefore, on habitat types present in the study area. These habitat types are described with a greater degree of specificity than in Chapter 3 since the study area can now be restricted to include only the region directly impacted by the project. Information on these habitats includes location in the project area, predominant floral and faunal types, probability of the presence of rare and endangered species, fragility (susceptibility to degradation by project-related activities), and "resource value". It is believed that this approach will provide a sound basis for a comparison of the ecological impacts of alternate plans and will indicate parts of the project area where detailed biological investigations and/or special mitigative measures may be required to minimize impacts in subsequent project stages.

Primary Impacts on Terrestrial Ecosystems

Three general groups of terrestrial habitat types in the project area are illustrated in Figure 69. Another general group, urban land, is illustrated in Figure 12 in Chapter 3. Basic habitat types within these groups are as follows:

1) Forested - Upland, slope and bottomland forests
2) Agricultural - Cultivated, pasture, old field (fallow)
3) Wetlands - Seasonally flooded, slow-draining bottomlands

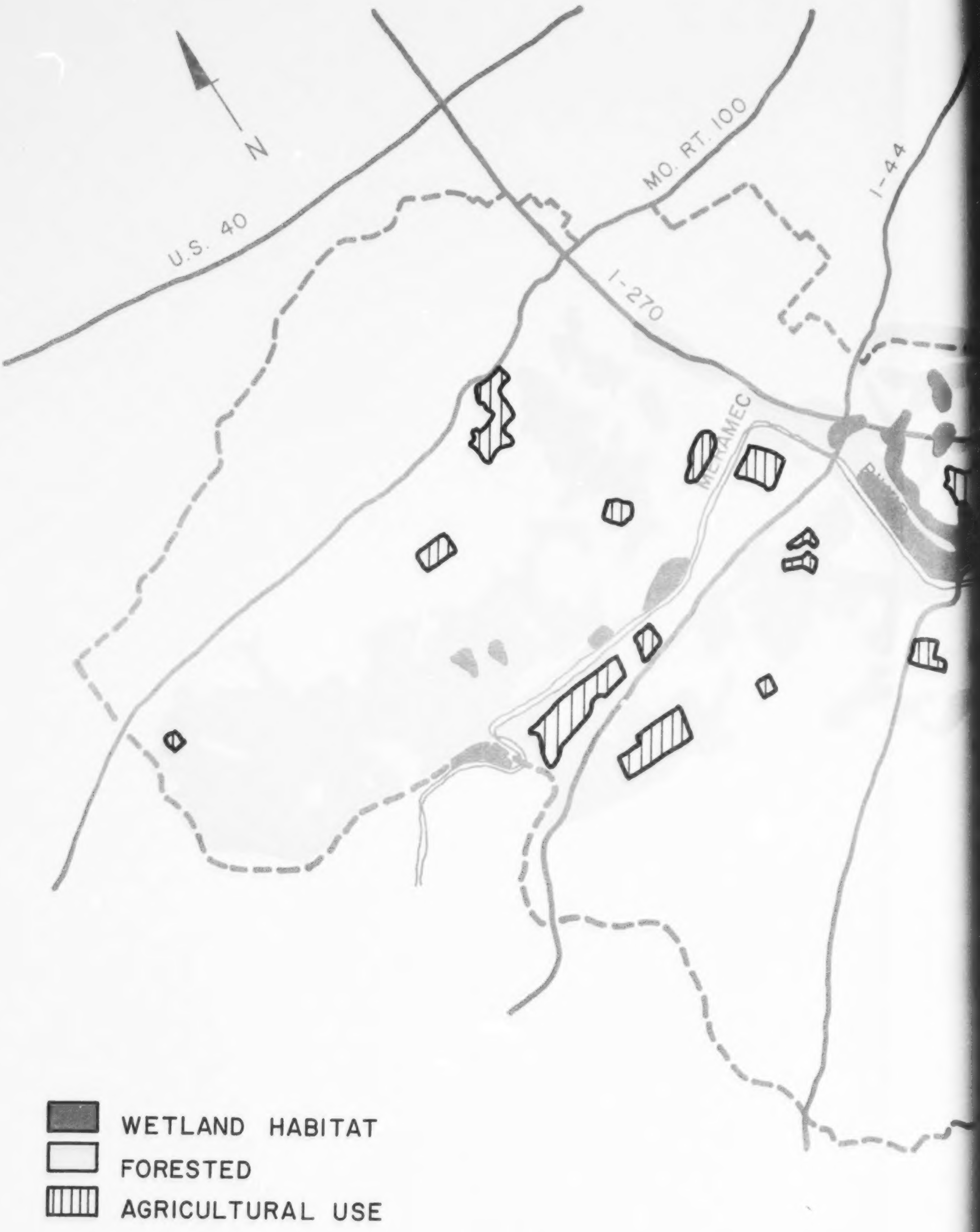
The floral and faunal compositions typical of these habitats are discussed in Chapter 3.

Table 52 shows the magnitude of surface disturbance which would occur in these habitats under project alternatives as illustrated in Figures 70 through 72. The calculations indicate only disturbances resulting directly from project activities involving construction or excavation. Since most of the habitat types grade into one another without any sharp division, slight changes in the alignment of plans could alter these figures considerably. However, the general orders of magnitude illustrated would remain the same.

As previously discussed, Table 52 does not represent a precise quantification of acreage impacted by the project. It is included, rather, to illustrate the general magnitudes of the impacts of project alternatives on terrestrial ecosystems. The calculations made are based on the following considerations and assumptions:

1) The actual acreage disturbed during construction of the various elements of the project will vary with geologic characteristics, design capacities, accessibility, topography, and other factors. Since this project is in the planning stage, it is impractical to assign precise quantities to all these project elements. It is therefore assumed, for the purpose of this comparison, that the extent of surface disturbance involved in construction of the major project elements will be as follows: sewage treatment plants - 1 acre/MGD; pumping stations - 1/2 acre; collector sewerage - 20 feet in width; main trunk conveyance sewerage (open-cut) - 75 feet in width; and drop shaft or construction shaft - 1/2 acre.

2) The three forest habitat types are significantly different from one another in terms of species composition and fragility. However, they grade


N
U.S. 40
MO. RT. 100
I-44
I-270
MERAMEC
RIVER
WETLAND HABITAT
FORESTED
AGRICULTURAL USE

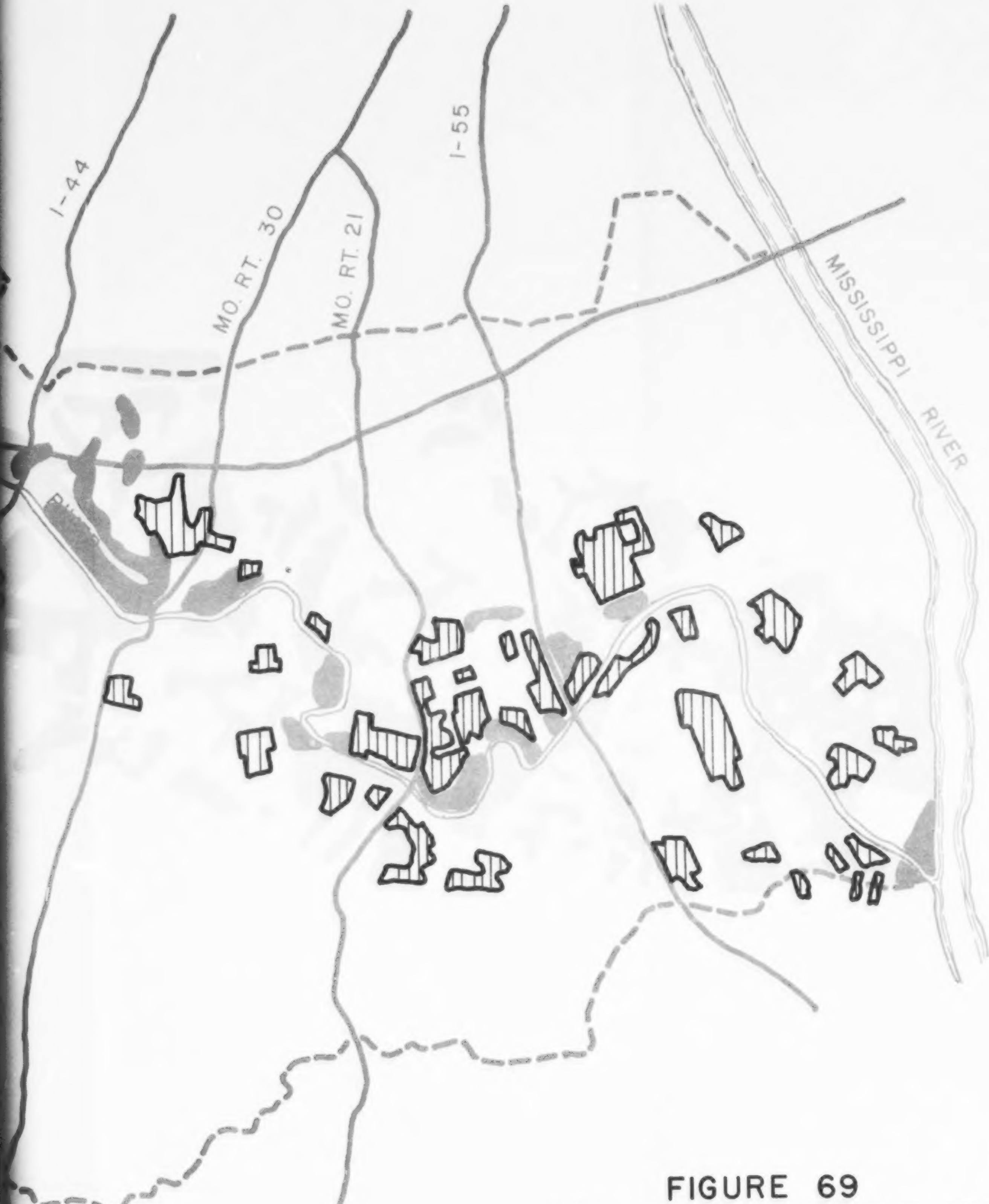
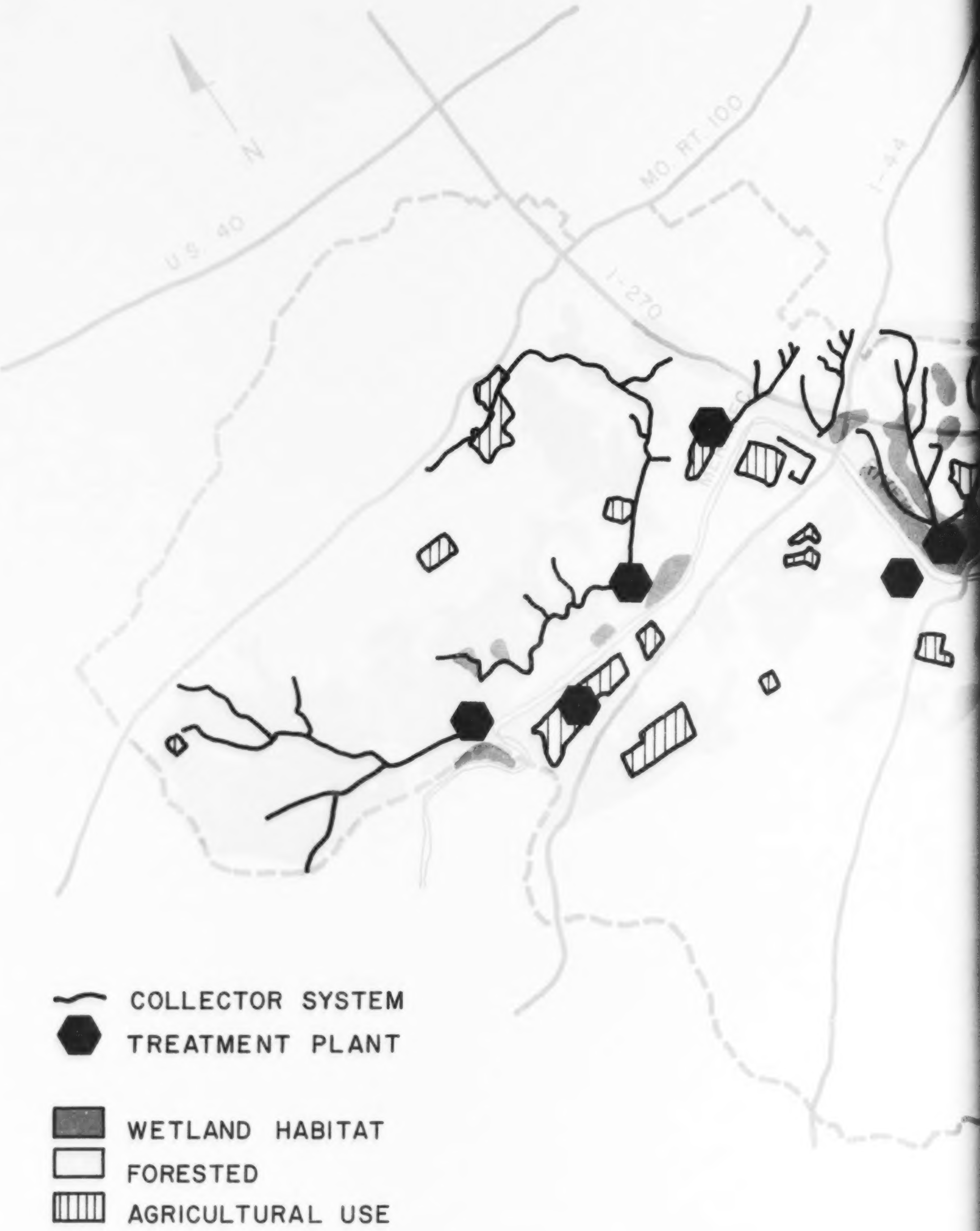

I-44
MO. RT. 30
MO. RT. 21
I-55
MISSISSIPPI RIVER

FIGURE 69
TERRESTRIAL HABITAT TYPES

TABLE 52

HABITAT DISTURBED BY CONSTRUCTION UNDER ALTERNATE PLANS (ACRES)

Alternative	Upland Forest	Slope Forest	Bottomland Forest	Wetland Habitat	Agricultural Land
Collector sewers (all "with project" alternatives)	3	38	7	3	4
Subregional Plan:					
Sewage Treatment Plants	2	3	3	5	6
Total (including collectors)	5	41	10	8	10
Regional Plan - Tunnel:					
Sewage Treatment Plants	-	-	8	-	21
Construction & Drop Shafts	-	2	3	2	2
Total (including collectors)	3	40	18	5	27
Regional Plan - Open-Cut:					
Sewage Treatment Plants	-	-	8	-	21
Pumping Stations	-	2	3	2	4
Main Trunk Conveyance	9	14	53	34	45
Total (including collectors)	12	54	71	39	74


N
U.S. 40
MO. RT. 100
I-270
I-44
COLLECTOR SYSTEM
TREATMENT PLANT
WETLAND HABITAT
FORESTED
AGRICULTURAL USE

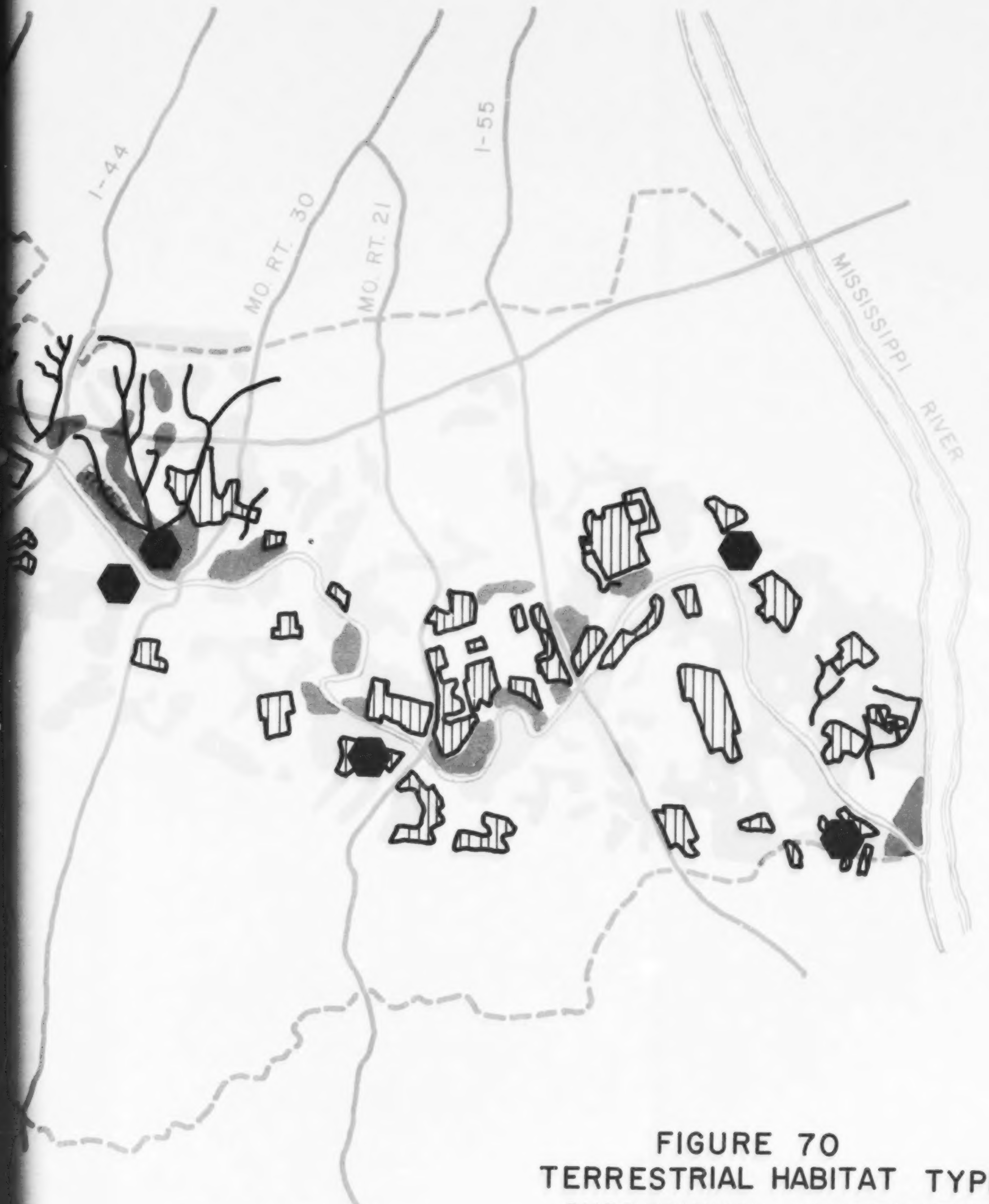
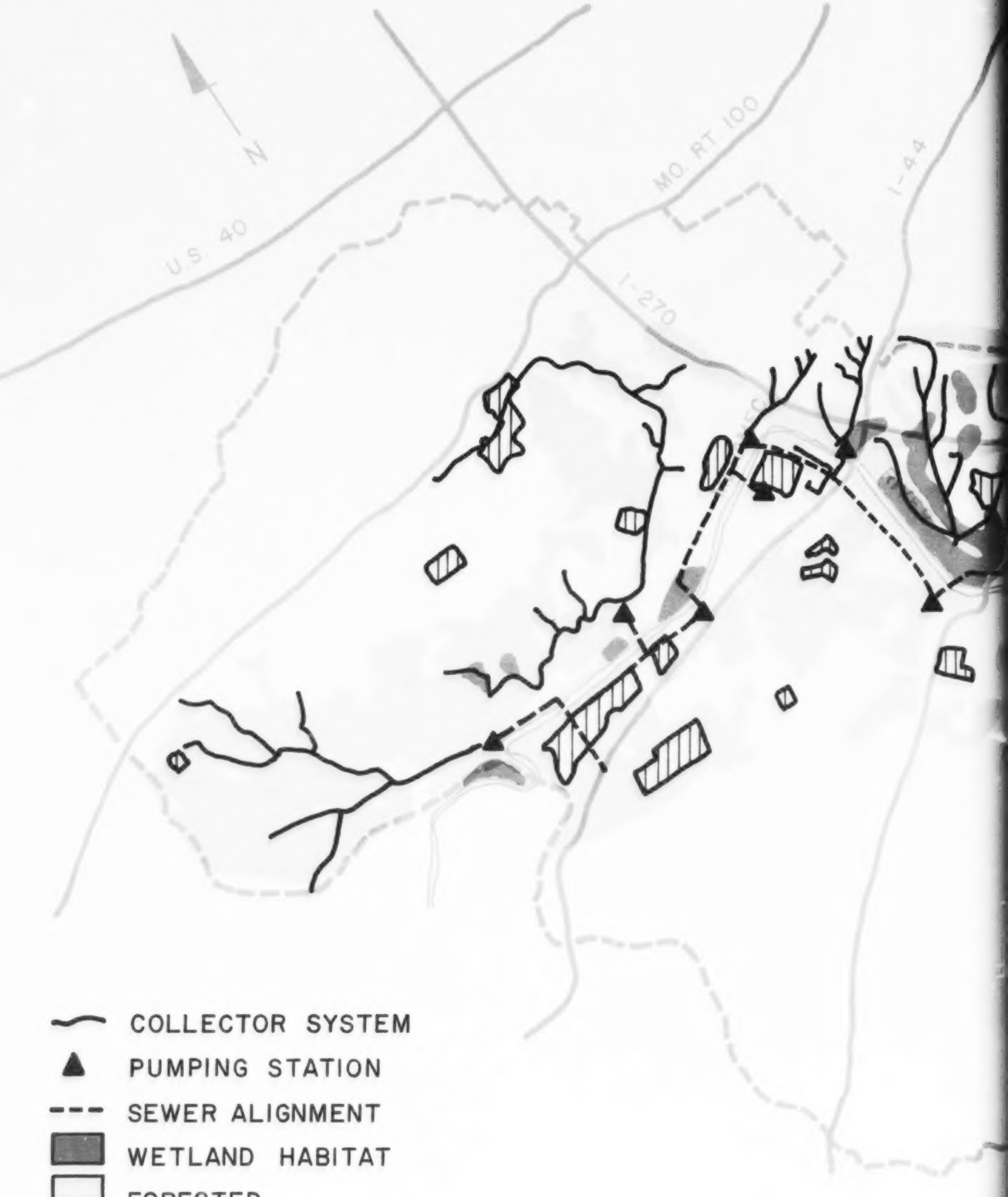

I-44
MO. RT. 30
MO. RT. 21
I-55
MISSISSIPPI RIVER

FIGURE 70
TERRESTRIAL HABITAT TYPES
SUBREGIONAL ALTERNATIVE


N
U.S. 40
MO. RT. 100
I-44
I-270
COLLECTOR SYSTEM
PUMPING STATION
SEWER ALIGNMENT
WETLAND HABITAT
FORESTED
AGRICULTURAL USE

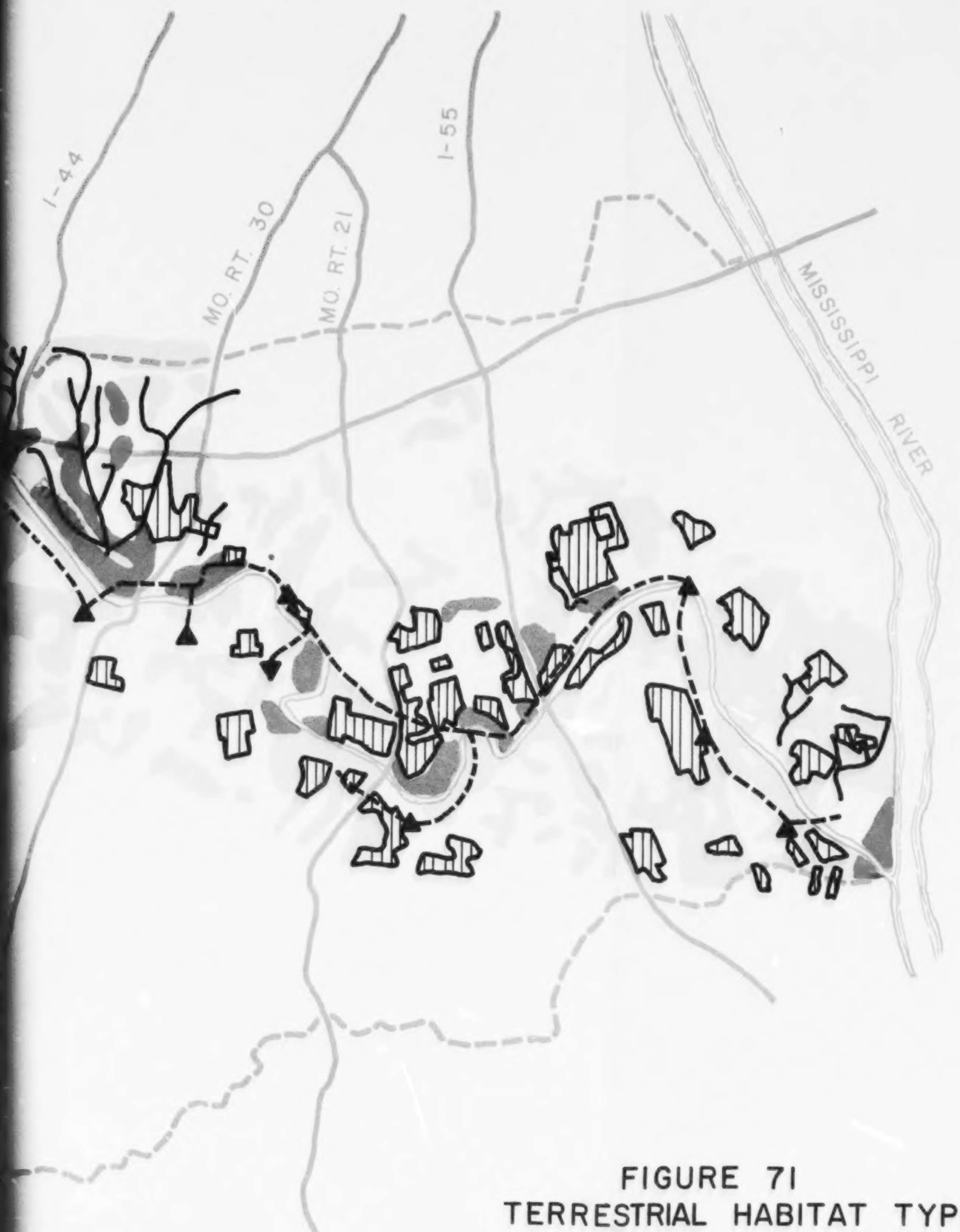
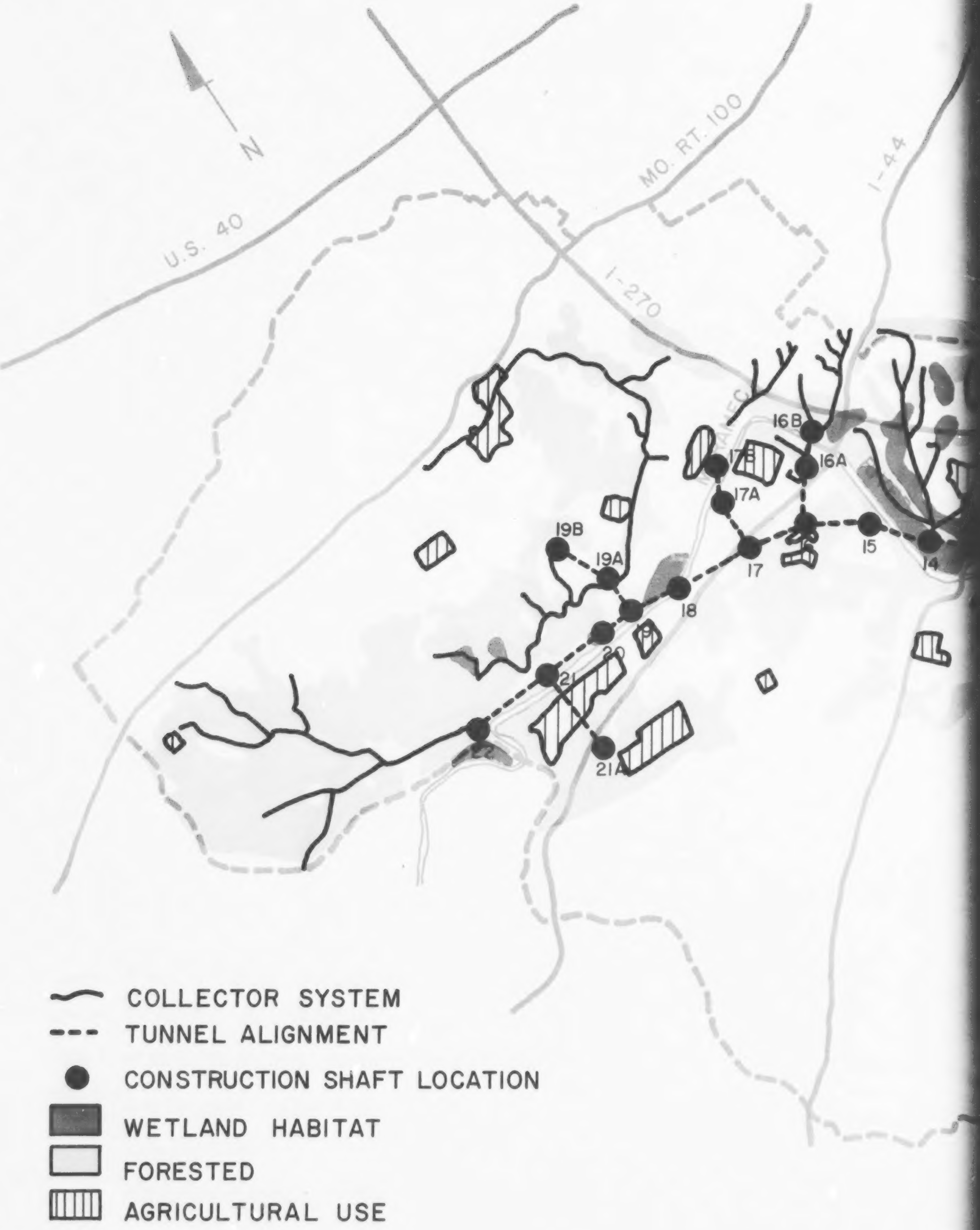

I-44
MO. RT. 30
MO. RT. 21
I-55
MISSISSIPPI RIVER

FIGURE 71
TERRESTRIAL HABITAT TYPES
REGIONAL ALTERNATIVE
OPEN CUT CONVEYANCE


N
U.S. 40
MO. RT. 100
I-270
I-44
MERAMEC
16B
16A
17B
17A
17
15
14
19B
19A
19
18
20
21
21A
22
COLLECTOR SYSTEM
TUNNEL ALIGNMENT
CONSTRUCTION SHAFT LOCATION
WETLAND HABITAT
FORESTED
AGRICULTURAL USE

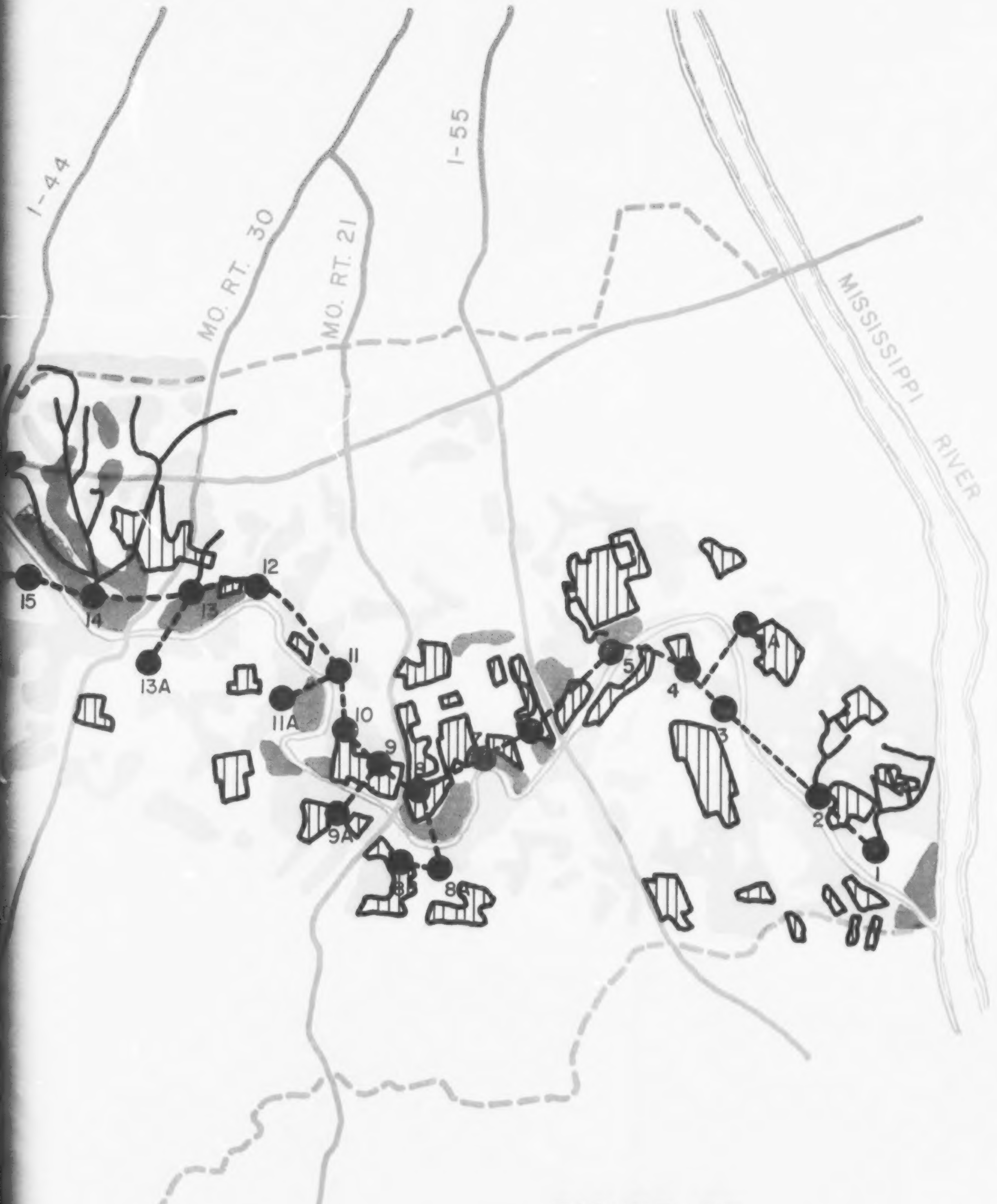

I-44
MO. RT. 30
MO. RT. 21
I-55
MISSISSIPPI RIVER
15
14
13
13A
12
11
11A
10
9
9A
8
8A
8B
7
5
4
3A
3
2
1

FIGURE 72
TERRESTRIAL HABITAT TYPES
REGIONAL ALTERNATIVE
TUNNEL CONVEYANCE

into one another, making precise delineation of their boundaries nearly impossible. The correlation between slope and habitat type is sufficiently strong, however, to allow for a meaningful separation of these habitat types on the basis of topography alone. This separation was made within forested parts of the project area by designating tracts on greater than 5 percent slopes as slope forests, thus making upland forests and bottomland forests easy to identify on the basis of their relationship to the alluvial valleys.

3) Much of the agricultural land in the project area is marginal in value. Thus, a given tract of land may be cultivated, used for pasturage, or left fallow in a given year. Therefore, the habitat types designated as cultivated fields, pastures and old fields are all included herein under the single category of agricultural land.

Upland Forests - Upland forests in the project area are located on hilltops, ridges, and just below the crests of hills. Upland forests gradually grade into areas of slope forest, but are distinct in terms of species composition. The predominant upland forest type in these area is oak-hickory. Much of the acreage in the project area which was formerly in this habitat type has been cleared for cultivation or urban development. Most remaining acreage is in small farm woodlots, although some larger tracts remain, especially in Jefferson County. Virtually all upland forests in the project area are second growth, having been cleared in the past for logging or cultivation.

Upland forests in the project area are valuable in terms of aesthetics, erosion control, and wildlife habitat. Edge created by interspersion of these forests with cultivated fields is of particular value to wildlife.

Relatively few species on either the Missouri or the United States list of rare and endangered species are found in the upland forests of the project area (115). Those which might be encountered in this habitat are as follows:

* Federal List (July 1977)
Endangered: Indiana bat (Myotis sodalis) which favors caves or overhanging ledges

* Missouri List (1974)
Endangered: Indiana bat and Keen's bat (Myotis keenii) which favor caves or overhanding ledges

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Rare: Shining clubmoss (Lycopodium lucidulum) which grows in crevices and limestone ledges

Red cedar (Juniperus virginiana var. crebra) which grows in dry limestone bluff areas

It should be noted that these species are restricted to dry limestone bluffs, caves, and overhanging ledges. If reasonable care is exercised to avoid such areas when developing detailed alignments, the impacts on any population of rare or endangered species should be minimal. If construction contracts specify that this care and standard erosion control measures be taken, the overall biological impacts on upland forests should be relatively slight.

Slope Forests - Slope forests in the project area are found on gradients generally greater than 3 to 5 percent. These forests grade into upland forests at the crests of hills and into bottomland forests on terraces and lowlands. Most forests in the study area are of this type since upland and lowland areas, with their gentler topography, have largely been converted to agricultural or urban uses. The predominant vegetation in these slope forests is oak, hickory and sugar maple.

As with upland forests, most slope forests in the project area are second growth, having been cleared for marketable timber in the past. They have significant value as watershed protection and as habitat for a variety of plants and animals including game animals, such as deer and squirrel, and several rare and endangered species. Rare and endangered species which may be found in slope forests include:

* Federal List (1977)
Endangered: Indiana bat as described previously

* Missouri List (1974)
Endangered: Indiana bat and Keen's bat as previously described

Cutleaved grape fern (Botrychium dissectum)
Pucoon (Lithospermum latifolium)
Black huckleberry (Guylussacia baccata)
Wild sasparilla (Aralia nudicaulis)
All these live on moist or north-facing slopes;

Wood frog (Rana sylvatica), which lives in slope forests in proximity to permanent pools of water

* Rare: Long-tailed weasel (Mustela frenata)

* Status Unknown: Regal moth (Citheronia regalis)

Due to the relatively steep grades, erodable soils, and rare and endangered species which may possibly be present in slope forests, the impacts of disturbances to this area are judged to be potentially significant.

Bottomland Forests - Bottomland forests in the project area are restricted to periodically flooded areas along the Meramec and the Mississippi Rivers. Most are dominated by sugar maple and bitternut hickory, with black willow and cottonwood located in areas subject to prolonged flooding. The principal resource values of these forests are slowing of flood waters, land stabilization, and retention of nutrients and organic chemicals from agricultural and urban runoff (115). Relatively few species of groundcover plants can withstand the frequency and duration of flooding in these forests. Consequently, the wildlife value of this habitat is relatively low. Rare and endangered species which may inhabit these forests are as follows:

* Missouri List (1974)
Endangered: Elms (*Ulmus* sp.)
River otter (*Lutra canadensis*)
Rattlesnake root (*Prenanthes racemosa*)

Rare: Four-toed salamander (*Hemidactylium sculatum*)
Double-crested cormorant (*Phalacrocorax auritus*)
Mississippi kite (*Ictinia mississippiensis*)
Northern bald eagle (*Haliaeetus leucocephalus alascensis*)
Least tern (*Sterna albifrons*)
Arrow arum (*Peltandra virginica*)
Orchid (*Spiranthes ovalis*)
Green adder's mouth (*Malaxis unifolia*)

Status Undetermined: Hedge nettle (*Stachys hyssopifolia*)
Graceful sedge (*Carex gracillima*)

* Proposed for inclusion on federal list (Smithsonian Institution, 1975): Small white lady-slipper (*Cyprepedium candidum*)
Boltonia (*Boltonia asteroides*)
Pale green orchid (*Platanthera flava*)

With the exception of the northern bald eagle, all of these species are dependent upon moist soil conditions for their existence. The characteristics of their habitat, in fact, show considerable similarity to those described below as wetlands. Due to these habitat characteristics, impacts of both surface disturbance and dewatering activities accompanying excavation may have significant impacts on populations encountered in bottomland forests.

Wetlands - Wetlands in the project area are often subcategories of the bottomland forest type, but also include shallow ponds and fallow, periodically flooded fields with slow-draining soils. These wetland areas are usually dominated by cattails, bullrushes, and grasses, with arrowhead and American lotus found in the wetter areas. The principal resource values of wetlands in the area are temporary storage of flood waters, retention of pollutants from runoff, and creation of wildlife habitat, especially for waterfowl. The types of rare or endangered species which may be found in wetlands of the project area are the same as those listed under the bottomland forest habitat type.

Surface disturbances, dewatering processes and disposal of excavated materials could have significant adverse effects on populations of these species. Surface disturbance will accompany the construction of sewage treatment plants, pump stations, construction shafts, and all open-cut sewage lines. The most significant adverse effects of this construction on wetlands will be direct habitat loss, modification of hydrologic conditions, and siltation. The relative magnitude of this disturbance under alternate plans is shown in Table 54. Treatment plants, pump stations, and those construction shafts which will remain for maintenance purposes will effect long-term impacts in the form of increased surface runoff and leaching of carbonates and coal-tar derivatives. These effects will be of the greatest magnitude under the subregional alternative (due to its numerous treatment plants) and the regional, open-cut alternative (due to the number of pumping stations involved).

Dewatering will be necessary during construction of all open-cut sewer lines which traverse areas with high water tables. In wetland areas, this would create drastic fluctuations in hydrologic conditions which would result in the degradation of the wetland areas affected on at least a temporary basis. These effects have the greatest impact under the regional, open-cut alternative, but could occur to some degree during construction of the lower portions of collector lines under all alternatives if the lines are not routed to avoid wetlands.

Disposal of excavated materials on wetlands would result in their degradation. Therefore, no such disposal is anticipated under any of the alternatives.

Complete mitigation of the damages to wetlands during construction of any of the alternate systems is not possible. However, the use of sediment curtains to avoid excessive silt deposition, halting of construction during sensitive spring months, and minimization of dewatering would minimize damages. Implementation of these measures, in addition to contract specifications requiring post-construction clean-up, would reduce damage to wetlands to near insignificance under the subregional and regional-tunnel alternatives. The regional-open-cut alternative would, however, still create serious impacts on wetlands due to the extensive dewatering which would be required.

Agricultural Lands - Agricultural lands in the project area may be divided into three general categories: cultivated fields, old fields (cultivation abandoned) and pastures. Most of the acreage in the project area which has a slope of less than 5 percent and which has not been developed for urban uses falls into one of these categories. Cultivated fields in the project area are generally cropped to soybeans, corn or wheat. Associated vegetation is principally weedy species characteristic of disturbed areas in the region. Their chief resource values lie in food production and forage and habitat provisions for numerous wildlife species. No rare, endangered or threatened species have been reported to inhabit or depend upon this habitat type. Cultivated fields are highly disturbed environments which have been subjected to years of topographic and groundwater manipulation. The primary adverse affects of project activities will be related to the pre-emption of land for long-term project activities (i.e., pump stations, access shafts, treatment plants) and the interruption of cropping schedules during construction.

Pasture areas principally contain herbaceous vegetation which are used for livestock grazing. Their species composition varies with the type of native vegetation formerly predominating, with grazing strategies, and with the level of planting practiced. Floral and faunal species are chiefly characteristic of disturbed areas and are generally widespread in geographic distribution. Pastures are, nevertheless, of value to many species of birds and small mammals. No plants or animals on or proposed for either the federal or state list of rare and endangered species are found primarily in the pasture habitat. Animals on one or more of these lists which might be occasionally found hunting there are:

* Federal List (1977)
Endangered: Peregrine falcon (Falco peregrinus), principally
a prairie species but hunts in old fields

* Missouri List (1974)
Endangered: Peregrine falcon as above
Upland plover (Bartramia longicauda)

Rare: Massasauga (Sistrurus catenatus)
Barn owl (Tyto alba)

Although pastures are not subjected to topographic or groundwater manipulation to as great a degree as are cultivated fields, pastures are highly disturbed environments which are subject to rapid, wide temperature fluctuation and considerable alteration of native vegetation. The principal project-related impacts affecting this habitat type under one or more of the alternate plans are similar to those listed for cultivated fields.

Old fields in the project area are found on lands which were once cultivated, used for pasture, or cleared for other purposes, and then abandoned. Their acreage varies annually with flood conditions, farm profit margins and cropping patterns. Their species composition varies according to native and surrounding vegetation and the time span since the last major disturbance. A typical succession in the project area commences with annual and biannual weeds, succeeded by grasses, mixed perennial herbs, shurbs, and then forest vegetation. The value of old fields as wildlife habitat varies with the stage of succession. Newer stages are of relatively low value while later stages provide excellent foraging, breeding, and wintering grounds for many species of birds and small mammals. No rare or endangered animals are found principally in old fields, although those listed as being found hunting in pastures may also use old fields for hunting. Plants on the Missouri 1974 list which may be found in this habitat are:

Endangered: Broom-rape (_Orobanche ludoviciana_)
Douglas' sedge (_Carex douglasii_)

Rare: White prairie aster (_Aster commutatus_)
Inland salt grass (_Distichlis stricta_)

Status Undetermined: Spring cocklebur (_Xanthium spinosum_)
Field sow thistle (_Sonchus arvensis_)

The impacts of the project on this habitat vary from very slight for newer fields to similar to those for forested tracts for older fields.

Urban Lands - For the purposes of this analysis, all lands developed for industrial, commercial or residential use are included in the urban land category, including areas with scattered residences and large acreages of lawn. Under this definition, less than one-fifth of the lands in this category are actually devoted to buildings and pavement.

Numerous species of plants and animals tolerant of disturbed and controlled environments abound in urban areas. The predominant plant species in lawns and vacant lots in the project area are Bermuda grass, Kentucky bluegrass, and a variety of introduced (native European) herbs, such as dandelion and plantains. Most of the trees found in these areas are silver maple, box elder, pin oak, sycamore and elm, with pines and upland oaks found in park areas. The diversity of animal life is low, but those species which are found in this habitat are relatively abundant. No rare or endangered species have been reported in urban habitats in the project area. Since these habitats are highly disturbed, controlled environments geared to supporting human populations, the impacts of the project alternatives on the natural environment of this area would be very slight.

Summary of Primary Impacts on the Terrestrial Environment

Table 52 presented the approximate acreage of the major habitat types described in this section which would be directly affected by each of the alternate plans. Table 53 presents an evaluation of each habitat type in terms of its degree of ecological fragility (susceptibility to degradation by project actions) and the extent of the potential threat project activities might present to rare and endangered species in each habitat type. For ease of comparison, these evaluations are ranked on a one to five basis, with one representing the smallest impact and five the greatest.

Table 54 was developed by combining information from Tables 52 and 53 to yield an impact index for each action alternative which indicates both the total extent of habitat disturbance under each plan and the potential impacts of that disturbance. The indices on Table 54 were developed as follows: the acreage of each habitat type under each alternative (from Table 52) was multiplied by the potential impact (PI) of construction in that habitat (from Table 53) to yield an impact index (II) for each alternate for that habitat type. These habitat IIs were then summed to derive a total II for that alternative.

It is important to note that these total impact indices are of value only in the context of comparing alternatives. They do not relate to any numerical scale, such as 0 to 2,000, for desirability of a particular plan, and are based on the assumptions discussed in the explanation of Table 52. Nevertheless, they do serve to indicate that the regional alternative, with cut-and-cover conveyance system construction, would have the greatest adverse impact on terrestrial ecosystems.

Secondary Impacts on Terrestrial Ecosystems

These secondary impacts are directly related to changes in land use which would be accommodated by implementation of one of the project alternatives other than the no action alternative. As

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TABLE 53

POTENTIAL IMPACTS OF PROJECT ACTIVITIES ON HABITAT TYPES OF THE PROJECT AREA

Habitat Type	Fragility	Rare/Endangered Species	Potential Impact
Upland Forests	2	2	4
Slope Forests	5	5	10
Bottomland Forests	3	4	7
Wetlands	4	4	8
Cultivated Fields	1	1	2
Pastures	1	2	3
Old Fields	2	3	5
Urban Lands	1	1	2

TABLE 54

IMPACTS OF ALTERNATIVE PLANS ON TERRESTRIAL ECOSYSTEMS

Alternative	Upland Forest			Slope Forest			Bottomland Forest			Wetland Habitat			Agricultural Land[(a)]			Total Impact Index
	PI	Acres	II	PI	Acres	II	PI	Acres	II	PI	Acres	II	PI	Acres	II	
Subregional Plan	4	4	20	10	41	410	7	10	70	8	8	64	3.5	10	35	599
Regional Plan Tunnel Conveyance	4	3	12	10	40	400	7	18	126	8	5	40	3.5	27	94.5	672.5
Regional Plan Surface-Cut Conveyance	4	12	48	10	54	540	7	71	497	8	39	312	3.5	74	259	1656

NOTES: [(a)] Potential Impact (PI) values for cultivated fields, old fields and pastures were averaged to obtain a PI value for this category.

in the Land Use Impacts section, it is here assumed (for comparative purposes) that no further urbanization will occur under the no action alternative after 1980 and that all of the action alternatives will accommodate the same growth for the design period.

Based on data and projections given in Chapter 3, approximately 800 additional acres in the Lower Meramec Basin will be devoted to commercial and industrial uses by the year 2000, if one of the action alternatives is implemented. Approximately 5,000 additional acres will be developed for residential use, assuming that present density levels of residential development continue under the regional and subregional plans. Thus, approximately 5,800 acres of project area lands will be converted from another land use to urban land use with the implementation of the project.

Figure 11 illustrates the three major Land Resource Areas (LRA) which comprise the study area. The LRA most suited to urbanization is deep loess uplands due to factors discussed in Chapter 3, such as soil types and topography. Most of the additional urban development can, therefore, be expected to occur in this LRA. The predominant existing land uses in this LRA are pasturage, cropping, timber production and urban development. Based on the habitat descriptions discussed previously in this report, the secondary impacts of project implementation may be established as the conversion of 5,500 to 6,000 acres to urban use with an accompanying reduction of biological productivity and species diversity.

The areas previously described as "wetland habitat" should not be directly affected by these land use changes. The very factors which make the areas suitable as "wetland habitat" (i.e., soil characteristics, landscape position, and frequency of flooding) make them unsuitable for developed uses. Unless flood control measures are implemented on the Meramec River, these wetlands will probably remain undeveloped or be converted to low-density recreation uses, which should have little effect on their ecological status. Increased development in adjacent upland areas would result in increased runoff and sedimentation. If this runoff is uncontrolled, the hydrologic status of the wetlands could be disturbed. Implementation of storm runoff plans as recommended in the areawide 208 Plan and construction specifications for developers would prevent such an occurrence.

Primary Impacts on Aquatic Ecosystems

Impacts of Operations - The water quality predicted for the Meramec River under the alternate plans will have a significant impact on the biological community. Parameters which will affect the biological community include biological oxygen demand (BOD), dissolved oxygen (DO), chlorine, nitrate, phosphate, ammonia and fecal coliform bacteria. The three proposed alternatives would produce varying levels of these parameters. However, in many cases no significant differences exist and, in some cases, the differences are relatively unimportant since the levels of these parameters will fall within biologically acceptable ranges.

Low nitrate and phosphate concentrations often limit the productivity of aquatic ecosystems. Conversely, abnormal increases in their concentrations will often result in algal blooms, which lead to eutrophication.

Nitrates and Nitrites: The proposed Missouri water quality regulations state that nitrate levels should not exceed the natural levels of the stream. Alternatively, the concentration of nitrate should not exceed 10 mg/l. The level of nitrates predicted under the regional alternative would not exceed 0.03 mg/l under normal dry flow conditions at any of the predicted sample points. This is the lowest maximum level of the alternatives considered. The subregional plan will result in nitrate levels of no higher than 0.375 mg/l during dry weather flow conditions. The no action alternative will result in a maximum nitrate level of 0.216 mg/l under the same conditions.

During high flow periods, the levels of nitrate-nitrogen are not predicted to vary significantly under the three alternative plans. The increased levels of nitrate-nitrogen are, therefore, unrelated to the alternate plans. The increased nitrate-nitrogen levels during periods of high flow would not adversely effect the aquatic community.

Similarly, the changes in nitrate-nitrogen concentrations during periods of extreme low flow would not have an adverse effect on the aquatic community.

The USEPA has proposed water quality criteria which would limit nitrite-nitrogen levels to 0.06 mg/l for waters, such as the Meramec River, inhabited by salmonids. Nitrite-nitrogen is an intermediate step in the production of nitrate-nitrogen. It is quickly oxidized to the nitrate form under normal conditions and, therefore, generally occurs in small proportions relative to nitrate-nitrogen. Due to this low ratio and the relatively low concentrations of nitrate-nitrogen under all alternatives, it is highly unlikely that any of the alternatives will result in nitrite-nitrogen levels that are detrimental to the salmonid populations on the Meramec.

In summation, levels of nitrates and nitrites predicted under all alternative plans would not result in significant nutrient loading or eutrophication of the Meramec. The biota would, therefore, remain that of an oligotrophic to a slightly mesotrophic environment. This type of environment is favorable to populations of salmonids, percids and centrarchids, which comprise the bulk of the game fish in the Meramec River.

Phosphate: Under both the regional and subregional alternatives, during normal, dry weather, low flow conditions, phosphate concentrations are not predicted to exceed the USEPA maximum recommended range of 10 to 30 μg/l. Under the no action alternative, the phosphate level is predicted to reach a maximum of 0.187 mg/l, which is above the recommended range and exceeds the USEPA desired limit on total phosphorus of 100 μg/l. The phosphate concentrations predicted under both the regional and subregional alternatives for these flow conditions are biologically acceptable since they do not alter the basic trophic condition of the streams involved.

The subregional plan would result in slightly higher productivity but would not produce a eutrophic condition. The trophic condition of the Meramec under the regional and subregional alternatives during periods with these flow conditions will be favorable for all preferred fish groups (salmonids, percids and centrarchids). The regional plan, however, would probably be slightly better for the clear water salmonids.

The no action alternative would contribute to hypereutrophic conditions in the Meramec River in terms of the concentration of phosphate. This trophic condition would put severe environmental pressure on clear water salmonids and would increase the suitability of the habitat for rough fish (cyprinids, catastomids).

During wet weather, high flow periods, the predicted maximum phosphate concentrations under the three alternate plans are approximately two and a half times the USEPA's recommended upper level for total phosphate. These levels are largely attributable to nonpoint sources, such as agricultural runoff, and would be of short duration. They would not, therefore, significantly alter the basic trophic condition of the streams concerned.

During periods of extreme low flow, both the subregional and the no action alternative will result in predicted phosphate concentrations that exceed the USEPA upper limit of 100 μg/l. Both of these alternatives would result in a biologically degrading hypereutrophic condition as described above. The phosphate level under the regional alternative would exceed the recommended range of 10 to 30 μg/l but would not exceed the upper limit and is, therefore, the best alternative in terms of the biological community.

Chlorine: No residual chlorine will result from the regional or no action alternatives during any of the flow conditions. Thus, both alternatives are equally acceptable for sustaining the biological community.

Under the subregional alternative, chlorine residuals would increase during periods of dry weather low flow by as much as 0.07 mg/l. This concentration exceeds the limits proposed by Missouri (0.01 mg/l) and those recommended by the USEPA (0.003 mg/l).

Residual chlorine levels under this alternative would be as high as 0.3 mg/l during wet weather, high flow conditions. The chlorine level under extreme low flow conditions would be 0.01 mg/l. The concentrations of chlorine during wet weather (0.3 mg/l) would be markedly higher than permitted by the state and the USEPA (0.05 mg/l) and would be biologically unacceptable, since these levels could be acutely toxic to trout and some of the other game fish.

Ammonia: Missouri's water quality standard for ammonia is a maximum concentration of 0.1 mg/l NH_3 as N. The proposed Missouri water quality standard and the USEPA standard maximum concentration is 0.02 mg/l NH_3 as N. Most ammonia in waters populated by fish is in the form of NH_4. The toxic form of ammonia is $NH_4OH(NH_3+H_2O)$; this is the form of concern to biological communities. The unionized NH_3 form increases in concentration from the total ammonia when there is an increase in pH or temperature or a decrease in DO. Therefore, the concentration of NH_3 is extremely variable in an aquatic system and, as a result, difficult to characterize in terms of the biological community.

Under the regional alternative, the predicted concentration of NH_3-N during normal dry, low flow conditions are within the proposed Missouri and USEPA standards. These predicted concentrations would have no effect on the biological community. Implementation of the subregional alternative would yield NH_3-N concentrations as high as 0.03 mg/l under these flow conditions. This level could be expected to have a slightly negative effect on the more tolerant species such as trout, but a very minimal effect on the biological community as a whole because of the infrequent and localized occurrence of concentrations this high.

The no action alternative would yield NH_3-N concentrations as high as 0.14 mg/l, which exceeds the current Missouri limit. Concentrations this high can be expected to adversely affect fish, especially the fry and fingerling salmonids. The most probable difficulties encountered by fish at these predicted concentrations would be physiological and histopathological with little or no increased mortality due to ammonia.

A rainfall event would increase the concentration of NH_3-N under both the regional and subregional alternatives to 0.142 and 0.143 mg/l, respectively. The increase under the no action alternative would be 0.164 mg/l. These predicted levels of NH_3-N could produce negative effects on the biological community, as noted above.

The biological community would not be significantly affected by NH_3-N levels produced during extreme low flow conditions under the regional plan. Under the subregional plan, extreme low flow conditions would produce a NH_3-N concentration of only 0.066 mg/l, which would be of no real biological importance. The no action alternative would produce NH_3-N concentrations as high as 0.421 mg/l and would be expected to have serious lethal as well as pathological effects on a wide variety of fish and some of the more sensitive macroinvertebrates.

Coliforms: Fecal coliform bacteria are used as indices of the pollution of waters by sewage. The State of Missouri sets standards for coliform bacteria based on the expected use of a given body of water. Those streams, such as the Lower Meramec River, which are expected to be used for "whole body contact recreation" are designated "Class A", and also have a coliform standard of 200 MPN/100 ml. During periods of low summer normal flow and also extreme low flow, both the regional and the subregional alternative produce extremely low (<20 MPN/100 ml) coliform counts and are therefore more than adequate for maintaining a high quality biological community. During rainfall events, coliform counts are higher than normal. These events are usually shortlived, however, (24 to 48 hours) and would therefore have only a minimal effect on the biota.

The no action alternative results in coliform counts in excess of 200 MPN/100 ml under all conditions. Fecal coliform counts would be 61,000, 28,000 and 162,000 MPN during summer normal, high rainfall events, and extreme low flow conditions, respectively.

Bacterial counts of this magnitude could be expected to adversely affect the biological community in at lease three distinct ways. First, the high concentration of bacteria increases the BOD significantly which results in a possible decrease in DO. Elevations in BOD and decreases in DO effectively limit the range of many species of fish and macroinvertebrates. Secondly, high levels of fecal coliform bacteria can have pathological effects upon aquatic organisms, especially fish. Wildlife that comes in contact with the stream, especially mammals, could contract diseases from the bacteria. Third, high concentrations of bacteria adversely effect the feeding mechanisms of a large number and variety of macroinvertebrates. The principle concern in this respect is with the filter-feeding invertebrates such as trichopterans and mussels. A decrease in the feeding efficiency of these organisms will result in lower rates of growth and reproduction. The resultant decrease in biomass of these macroinvertebrates would cause a shift in many parts of the food web.

Biochemical Oxygen Demand: BOD was predicted to reach a maximum of 1.1 mg/l for normal summer flow, under the regional plan. The same flow condition resulted in maximum BOD values of 1.5 and 2.7 mg/l for the subregional and no action alternatives, respectively. The biological impact of these values would be insignificant. BOD values in this range are generally indicative of a healthy stream with little organic loading.

Maximum BOD levels of 10.9, 10.9 and 11.1 mg/l were predicted for the regional, subregional and no action alternatives during a rainfall event. These values are not significantly different and are probably not related to the treatment alternatives. If BOD levels remain above 10 mg/l for extended periods, the amount of oxygen dissolved in the water will be greatly reduced. The biological impact of low levels of DO are discussed below.

During periods of extreme low flow neither the regional nor the subregional alternative would produce BOD levels that would cause any significant impact on the biological community. The no action alternative, however, was predicted to result in a maximum BOD of 5.3 mg/l under extreme low flow conditions. This value could cause an acute reduction in the DO level and, thus, have a significant adverse biological impact.

BOD, as an independent measure, can be used superficially to determine impacts on the biological community. It is best, however, to independently analyze each of the factors responsible for the BOD so that if a high BOD is present, the probable cause can be determined. Additionally, it is necessary to know the physical conditions of the river before one can understand the impacts of a high BOD. In summation, it is necessary to analyze the individual oxygen-consuming and oxygen-producing processes before realistically assessing the biological impact of a BOD.

Dissolved Oxygen: Under all three plans, the minimum concentration of DO during normal summer and extreme low flow conditions would exceed Missouri and USEPA proposed water quality criteria of 5.0 mg/l. Under all three plans, during normal summer flow conditions all DO levels were above 7.0 mg/l and during extreme low flow, the minimum predicted value was 6.2 mg/l. These high DO levels provide the necessary oxygen for a healthy and diverse biological community, in terms of both growth and reproduction.

During conditions of high flow caused by a rainfall event the minimum DO level under all three treatment alternatives was predicted to be as low as 2.8 mg/l. The similarity of the values for the three treatment alternatives indicates that the reduction in DO is probably independent of the treatment plan chosen. The biological community could be expected to respond to reduced DO conditions with a shift in population structure, dictated by physiological responses. A reduction in DO for short periods of time would probably have no lethal effect upon the community. However, reproduction among a number of species could be expected to be reduced or eliminated. A number of macroinvertebrate species undergo a reduction in reproductive energy and efficiency with reduced DO. Many fish species require high DO levels (5.0 to 6.0 mg/l) for the aeration of eggs and the successful hatching of fry. Foremost among the fish are the trout (salmonids) which require DO levels of at least 5.0 mg/l in the interstitial water of the stream bed for survival of the eggs.

A prolonged period of DO reduction (lasting up to several weeks) may cause a shift in the species composition. The more sensitive species could be expected to migrate out of an area because of modifications in behaviorial or physiological processes caused by the reduced DO level. Species tolerant of reduced oxygen concentrations would then be able to expand either their range or density due to the reduced interspecific competition for living space and food. This type of species shift, however, would not be probable in the Meramec since the DO concentration would only be reduced for a short period of time following a rainfall event.

Tributary Streams - The no action alternative's impact on the biological communities in streams tributary to the Lower Meramec will be variable but can generally be classified as unacceptable. Ammonia, nitrate, fecal coliform and DO levels will violate state and federal standards and, along with BOD, will be environmentally degrading. The extremely high levels of nitrate (5 to 10 mg/l as N) will be toxic and fatal to most forms of life in the streams.

The regional and subregional alternatives will improve the biological state of the tributary streams. DO, nitrate and phosphate levels will be within state and/or federal guidelines. Fecal coliform counts will be greatly reduced to 500 MPN/100 ml which is above state standards but is a marked improvement. BOD will be reduced dramatically and this may serve as an indicator of the improvements generally resulting from the stoppage of sewerage discharge under the two treatment alternatives.

Mississippi River - The impact of the three alternate plans on the Mississippi River will be minimal and, for the most part, negligible. Three areas of concern are worth noting. Ammonia levels will be increased by 0.4 mg/l under the regional plan. This is a serious increase in the mixing zone but should have little impact on the river. The localization of this effect will minimize the adverse impacts on the biological community.

The subregional alternative would increase the NO_3-N by about 0.5 mg/l which, again, is insignificant in terms of the resources of the Mississippi River. The fecal coliform increase resulting from the no action alternative, 25,000 MPN/100 ml, is significant and will add a substantial burden to the river. However, although the biological effects will be noticeable, they will not be acute and the river will not be seriously degraded by the burden. In terms of the quality of life in the Mississippi, the subregional plan is the best alternative since the regional plan will cause an increase in toxic ammonia and the no action alternative will increase the fecal coliform level.

Table 55 presents the major water quality parameters affecting aquatic organisms during this project and the effects of the alternate sewerage plans on these parameters. The scoring system used in the table is as follows:

A score of 1 represents the "best" of the three alternatives in terms of a given parameter; 3 is the "worst". Judgemental ties are averaged. Scores for all parameters are totalled and divided by nine (number of categories scored) to obtain an average. The lowest average score indicates the best alternative in terms of the parameters considered.

Construction Impacts

The impacts of project construction on the quality of water in streams in the project area are discussed in the Impacts on Geology and Groundwater section of this chapter. They may be briefly summarized as follows:

1) Minor, localized increases in sediment loading during construction of collectors

2) Significant additions of suspended solids and turbidity of water proximate to river crossing sites during construction of the cut-and-cover conveyance system

3) Elevation of chloride levels in waters proximate to dewatering sites under both regional alternatives, although not to levels exceeding 500 mg/l

TABLE 55
COMPARISON OF AQUATIC PARAMETERS

Parameter	No Action	Subregional	Regional
Nitrate	3	2	1
Phosphate	3	2	1
Chlorine	2	3	1
Ammonia	3	2	1
Fecal Coliform	3	1.5	1.5
BOD	3	1.5	1.5
DO	2	2	2
Tributaries	3	1.5	1.5
Mississippi	3	1	2
Average	2.77	1.83	1.16

The impacts these water quality changes are predicted to have on aquatic ecosystems of the project area are:

1) The localized increases in sediment loading accompanying construction of the collector system would have significant adverse effects in locations where the loading coincides with spawning areas or where concentrations of filter-feeding organisms are found

2) Under the regional alternative using open-cut construction of the conveyance sewer, significant amounts of additional suspended solids and increases in turbidity at river crossing sites would result in decreased photosynthetic activity, decreased visibility and accompanying behavioral aberrations for aquatic fanua, increased water temperatures, decreased dissolved oxygen levels, and interference with sensory mechanisms vital to filter-feeding in certain benthic organisms.

The pH values would be lowered in localized areas where anaerobic sediment layers are disturbed. While this acidification probably would not be extensive enough to create biological problems in itself, the altered pH condition could act in concert with the combination of factors listed above to create inhospitable conditions for many aquatic floral and faunal species.

In addition to the above-mentioned impacts, two construction activities required under one or more of the alternatives could result in the extensive direct destruction of aquatic habitat, especially for benthic organisms. These two activities are the excavation of small stream beds for construction of collector lines, and the excavation of sections of the Meramec River bottom for crossings under the regional open-cut alternative.

As cited in Chapter 3, several rare mussels have been reported in the Meramec. The effects of a temporary increase in sediment loading on these organisms is unknown. Employing the mitigating measures mentioned in the previous section on wetlands will, however, minimize these effects. Long-term water quality improvements would benefit this fauna.

Secondary Impacts on Aquatic Ecosystems

The existing Lower Meramec watershed in the study area contains considerable acreage of forested and wetland habitat. The forest cover retards runoff and aids in controlling erosion. Wetland areas act as sinks for nutrients and toxic substances in runoff from upland urban development and cultivated fields. Under the no action alternative, these characteristics would not be altered significantly. Under this alternative, however, existing overloaded sewerage systems would continue to contribute pollutants to the watershed.

The urban development which is anticipated subsequent to implementation of the action alternatives would result in the conversion of approximately 5,800 acres of vacant, agricultural, forested and wetland areas to urban uses by the year 2000. If not controlled by upgraded storm sewer systems, runoff from this acreage will contribute additional hydrocarbons and heavy metals to streams in the area and will result in increased stream flow fluctuations and rises in water temperature. These changes could have significant adverse effects on aquatic life.

Mitigating Measures

The following measures should be considered in subsequent planning and project design in order to minimize the extent of the adverse impacts discussed in previous sections:

1) Subsequent to making final calculations on methods and routes of excavation, those routes traversing areas which are most likely to contain rare or endangered species, significant wetland areas, or cultural resources (referred to hereafter as "resources") should be surveyed by persons qualified in the detection of those resources. Areas in which such resources are discovered can then be avoided.

2) To the extent possible, structures such as pumping stations, sewage treatment plants, and construction shafts should be located in the less fragile habitat areas such as agricultural lands or upland forests.

3) All construction activities taking place in areas with relatively steep topography should be carried out with full attention to erosion control.

4) To the extent possible, construction which could affect aquatic habitats should be scheduled to avoid spawning or breeding seasons for the predominant species. The optimum construction period in this regard would be middle to late summer. The period during which the greatest adverse effects would take place is spring.

5) Trench walls in ecologically or archaeologically sensitive areas should be kept as nearly vertical as possible through the use of reinforcing walls. This expensive procedure should, however, be restricted to those areas identified as sensitive in the survey mentioned above or where other developed uses would otherwise be degraded.

6) In areas where extensive dewatering of sand and gravel would affect sensitive resources or developed uses, trench walls should be grouted.

7) When return water from dredging operations, tunnel seepage or runoff from construction areas contains extensive quantities of suspended solids, this water should be routed through settling basins prior to being discharged to streams.

8) Seepage water having a high chloride content should be routed directly to the Meramec rather than to smaller tributary streams.

9) All construction equipment should be properly muffled and operated only during the less sensitive hours (from 7 a.m. to 6 p.m.)

10) Treatment plant designs should include features which minimize acoustic, aesthetic, and air and water quality problems. Such features should be site-specific. Potential aerosol or odor sources should be placed where they can be readily dispersed by natural air movement, downwind (in terms of prevailing winds) from sensitive receptors, when practical, and should be covered when no other solution exists. Sources of excessive noise within the plants should be isolated from employee work areas or the levels of noise properly attenuated. Sound barriers should be constructed where excessive noise would effect surrounding sensitive environments. Buildings should be oriented to present the view of the plant most compatible with the surrounding area. Lighting should be oriented to avoid off-site glare.

LAND USE IMPACTS

This section is devoted to a discussion of impacts on land use in the study area. The potential impacts are discussed in two categories: primary impacts and secondary impacts. Primary impacts are those which would be directly attributable to the construction and operation of the project alternatives. Examples of primary impacts are pre-empting of land for pollution control uses and temporary disruption of other uses during construction.

Secondary impacts are those effects which, while not resulting directly from a project, are known to occur commonly in association with the implementation of such projects. Examples of secondary impacts are population increases or industrial/commercial growth which the project would accommodate.

This EIS uses a broad interpretation of what constitutes a secondary land use impact. The wastewater problem in the Lower Meramec Basin is so critical that the Missouri Clean Water Commission has contemplated a ban on future sewer extensions or additions in portions of the study area, if ameliorative procedures are not taken. Such a ban would, most likely, result in a halt of residential, commercial, and industrial development. It is here assumed that implementation of the no action alternative as described in this EIS would lead to a ban on future sewer extensions or additions. Therefore, the no action alternative is also a no growth alternative. All future development in the study area is, therefore, expected to occur only after implementation of an action alternative and is herein considered a secondary land use impact.

In this section, primary and secondary impacts related to implementation of the regional and subregional wastewater management alternatives are discussed and compared with impacts associated with the no action alternative.

Secondary Impacts

Secondary impacts on land use are associated with the phenomenon of "induced growth", the development projected to accompany implementation of the project. The discussion of induced growth effects in this section compares the projected results of the no action or no growth alternative with the projected results of the regional and subregional alternatives. It is important to note that:

1) Project area growth need not be directly attributable to the regional and subregional alternatives, which will be included herein as induced growth.

2) It is debatable whether growth in the project area would actually be halted without implementation of the regional or subregional alternatives

3) If growth of the St. Louis area occurs as projected, a ban on sewer connections in the study area would induce growth in another part of the

> St. Louis area. Hence, the adverse impacts projected to accompany the project would simply be shifted elsewhere within the St. Louis area.

Table 56, which is based on projections by the East-West Gateway Coordinating Council (018), presents a comparison of population and land use characteristics projected for the years 1980 to 2000. The 1980 figures are considered to be representative of the no action alternative for the purposes of this study. The year 2000 figures are considered to be representative of either of the other alternatives.

As shown in Table 56, significant increases in population and acreage devoted to commercial/industrial uses are projected for the study area if the regional or subregional alternatives are implemented. Degrees and types of growth projected vary by watershed. The impacts of this growth on land use are largely determined by two sets of factors: the physical suitability of the lands for development (as juxtaposed with their value for other uses); and, the extent and quality of planning and zoning efforts to guide this growth. Analyses of land suitability (017,018) in the study area indicates that the various watersheds can absorb projected growth without the development of lands which are either unsuitable for development or better suited to other uses. The occurrence of such suitable development would, however, be dependent on careful planning and the promulgation and enforcement of zoning ordinances.

Primary Impacts

The most significant long-term primary land use impacts of the regional and subregional alternatives will result from preempting of land for sewage treatment works and appurtenances. Although plans for these works have not been produced and their final design capacities have not yet been developed, it is possible to obtain a comparative approximation of the land requirements for each alternate, based on estimates of future design wastewater flow as cited in the Draft 201 Facilities Plan for this project. Such an approximation has been developed, as shown in Table 57, by using an acreage requirement of 1 acre per 1 million gallons per day plant capacity and the year 2000 as the design year. Acreages are presented both for the total study area and disaggregated by watershed. This disaggregation is of importance in evaluating the impacts of pre-empting land for the following reasons:

1) Land use patterns and densities of development vary among watersheds

TABLE 56

DEMOGRAPHIC AND LAND USE PROJECTIONS UNDER REGIONAL, SUBREGIONAL AND NO ACTION OPTIONS - YEAR 2000

	No Action[a]		Regional and Subregional	
Watershed	Population	Commercial/ Industrial Acreage	Population	Commercial/ Industrial Acreage
Keifer	2,581	57.7	4,800	75
Grand Glaize	42,836	934.7	55,000	1,180
Fishpot	21,420	176.2	27,000	290
Yarnell	3,644	49.4	4,300	52
Fenton	3,158	75.0	4,200	92
Meramec I & II	1,626	16.7	1,800	18
Meramec III	1,165	173.1	1,500	177
Meramec IV	1,066	67.9	1,500	83
Meramec V	1,025	698.2	1,200	702
Meramec VI	3,477	138.8	5,800	200
Meramec VII	5,532	185.8	9,000	252
Meramec VIII	2,854	22.9	2,900	24
Mattese	28,317	514.6	34,000	650
Martigney	9,167	178.4	12,000	240
Mississippi Tributary Area	3,758	232.3	4,300	242
Northern Jefferson County	35,909	315.1	53,000	393
Total	167,535	3,837.8	222,300	4,670

NOTES: (a)No growth is assumed beyond 1980 under no action option.

TABLE 57

COMPARISON OF ESTIMATED LAND REQUIREMENTS FOR TREATMENT PLANTS UNDER SELECTED ALTERNATIVES ACREAGE IN YEAR 2000

Watershed	No Action[(a)]	Subregional	Regional
Keifer	0.3	0.8	-
Fishpot	2.8	3.7	-
Meramec I	0.1	-	-
Grand Glaize	5.9	8.8	-
Meramec II	0.1	-	-
Meramce III	0.1	-	-
Meramec IV	0.1	-	-
Meramec V	0.7	4.1	-
Meramec VI	1.2	1.7	-
Yarnell	0.5	-	-
Fenton	0.8	-	-
Meramec VII	0.8	-	-
Meramec VIII	0.9	7.0	28.6
Mattese	2.6	-	-
Northern Jefferson County	3.2	11.7	9.2
Total	20.1	37.8	37.8

NOTES: (a) Assumes no growth or development in project area, (i.e., 1975 flows)

2) Degrees of compatibility between treatment plants and surrounding land use would, therefore, vary among watersheds

3) The quality (or value) and sensitivity of resources disrupted by project implementation vary among watersheds

It is important to note that the land requirements given in Table 57 include only land required for the treatment plants themselves and are estimates based on projections of population and land use trends, tentative siting plans, and design contingencies requiring detailed study. They should, therefore, be regarded as indices of land requirements and should be used only in comparing land use impact magnitudes.

As shown in Table 56, total acreage requirements will be the same for the subregional and regional alternatives, while those for the no action (in this case, no growth) alternative would be approximately 50 percent less. In comparing the impacts of these land requirements, however, the characteristics described in the following paragraphs must be considered.

1) The actual acreage required for the operation of a treatment system is considerably greater than that occupied by the plant itself. Additional land is required for site access, equipment storage, and other support facilities. In addition to the acreage occupied by these facilities, an "area of direct influence" surrounds each facility. This area is strongly affected by the noise, odors, and activity accompanying the operation of each plant. Thus, the duplication of access roads and storage areas and the dispersal of these "areas of influence" necessary for the no action and subregional plans would mean that the actual acreage affected by these plans will be far greater than that affected by the single regional plant.

2) Additional capacity is required at each plant to provide for peak flows, flexibility for future growth, and for "standby" process facilities to be used during maintenance or emergency shutdown of facilities. An "economy of scale", in terms of land required, is realized by consolidation of facilities. Thus, total additional land of this type would be less under the regional alternative than under the other two alternatives.

3) The size of a plant's area of influence is largely dependent on the sensitivity of adjacent land uses. The single, regional plant would be adjacent to the Union Electric Company's Meramec facility and would be situated in a floodplain area which is likely to remain undeveloped because of frequent backwater flooding from the Mississippi. Under this alternative, existing plants would be phased out, making additional land available for other purposes. Existing plants, conversely, are dispersed throughout the project area and are situated adjacent to a diversity of land uses, including single-family dwellings and parks.

Additional primary land use impacts would occur under the regional and subregional alternatives as existing plants are enlarged or phased out of use. Under the subregional alternative, a number of plant sites would be phased out and others enlarged in capacity. Under the regional alternative, the existing treatment plants would be phased out and the acreage pre-empted for sewage treatment would be centered at a single location. The land released under either alternative could be developed for other economic or recreational uses.

In summation, future land use under the no action alternative would remain as it is at present, with dispersed treatment facilities occupying sites throughout the study area. Some of these sites are adjacent to highly sensitive uses. Under the subregional alternative, some of these plants would be phased out. However, approximately eight plants would be constructed or modified. These would be larger than existing plants and each would require support facilities and access roads. A single regional plant would eliminate existing plants, localize impacts in a relatively nonsensitive area, and realize an "economy of scale", relative to land required for support and access.

ECONOMIC IMPACTS

It is assumed throughout this report that failure to upgrade the sewerage system in the study area would result in the placement of a construction ban. Such a ban would, in turn, halt growth and development and limit the expansion of the area's tax base. Either of the action plans would, however, provide service adequate for projected development.

The regional and subregional alternatives would require the preemption of land for treatment plants and appurtenances. At least some of this land is presently privately owned and taxable. It is expected that the operation of treatment plants under either of these alternatives would be by the public sector. Any land taken for the proposed wastewater treatment plants would thus be removed permanently from the tax roles. Because the total acreage which would be removed from the tax roles would probably not exceed 40 acres, however, these alternatives are not expected to have a significant adverse impact on local municipal tax bases.

At the same time, either of the action alternatives would include phasing out some existing plants. This land could be utilized for higher economic uses which would generate additional tax revenue. This is not expected to be of major benefit to any local municipality.

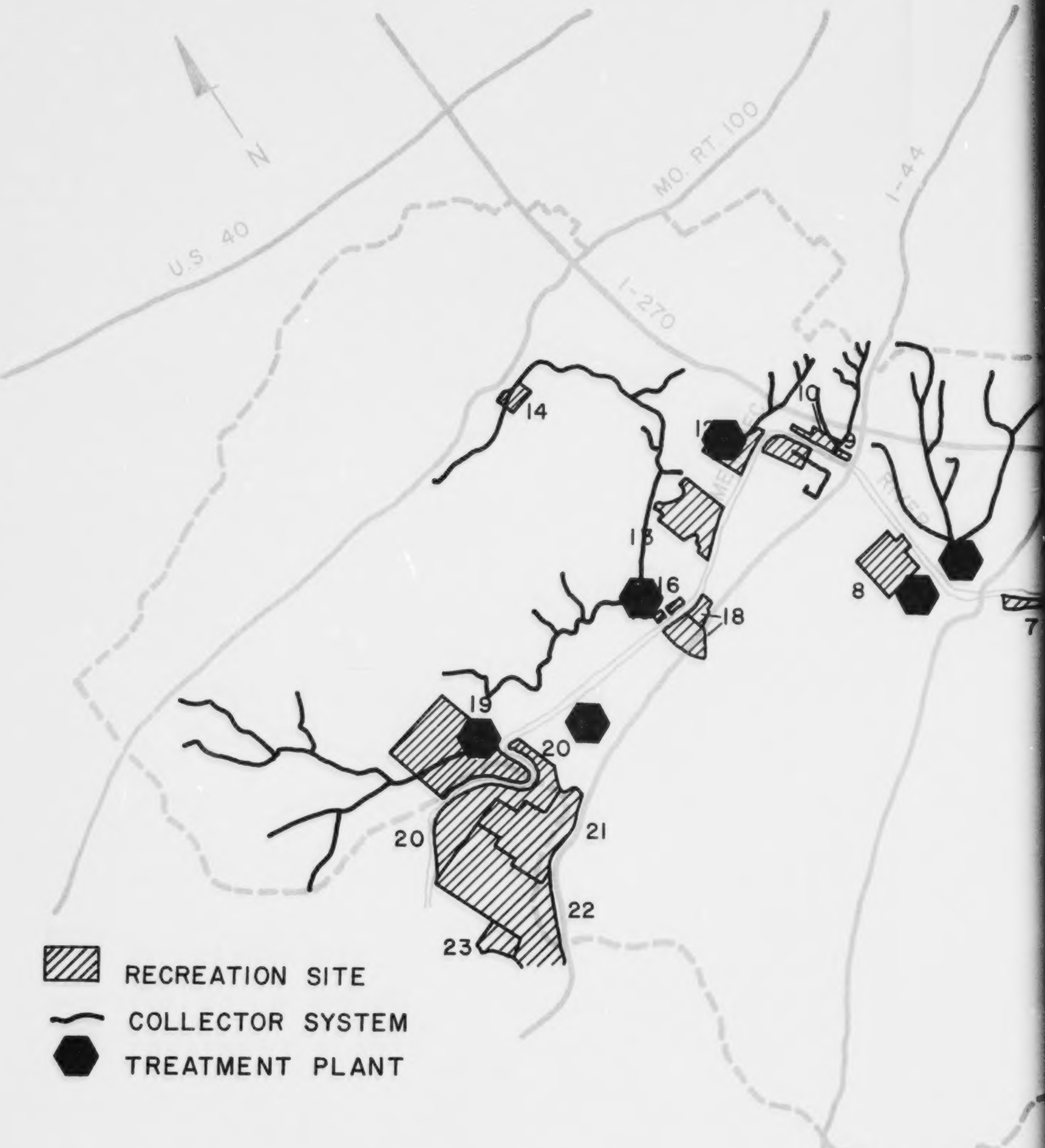
The public sector agency involved in land purchases for this project would be required to pay adequate compensation to any private property owner whose property would be taken or damaged. The taking or damaging of property is, therefore, not expected to constitute a beneficial or adverse impact.

The action alternatives would generate a demand for labor and construction materials and services. This demand would contribute to economic growth in the region. According to the St. Louis Regional Commerce and Growth Association, each construction dollar will generate an additional $1.34 in goods and services in the region.

IMPACTS ON RECREATION

The principal recreation sites in the project area are described in Table 10 and shown on Figure 13. As evidenced by the extent and distribution of these areas, recreational areas are an important part of the area's land use. This section discusses the primary and secondary impacts of the project alternatives on these recreation areas. This discussion of primary impacts is based on other analyses conducted in areas such as noise, water quality, and biology and on overlays of Figure 13 with maps of the project alternatives (Figures 73, 74 and 75).

The extent of the impacts on recreation is dependent upon the amount of terrain that will be disturbed and on the degree to which a recreational experience will be disturbed by the noise,


N
U.S. 40
MO. RT. 100
I-270
I-44
14
12
10
13
16
18
8
7
19
20
20
21
22
23
▨ RECREATION SITE
COLLECTOR SYSTEM
⬢ TREATMENT PLANT

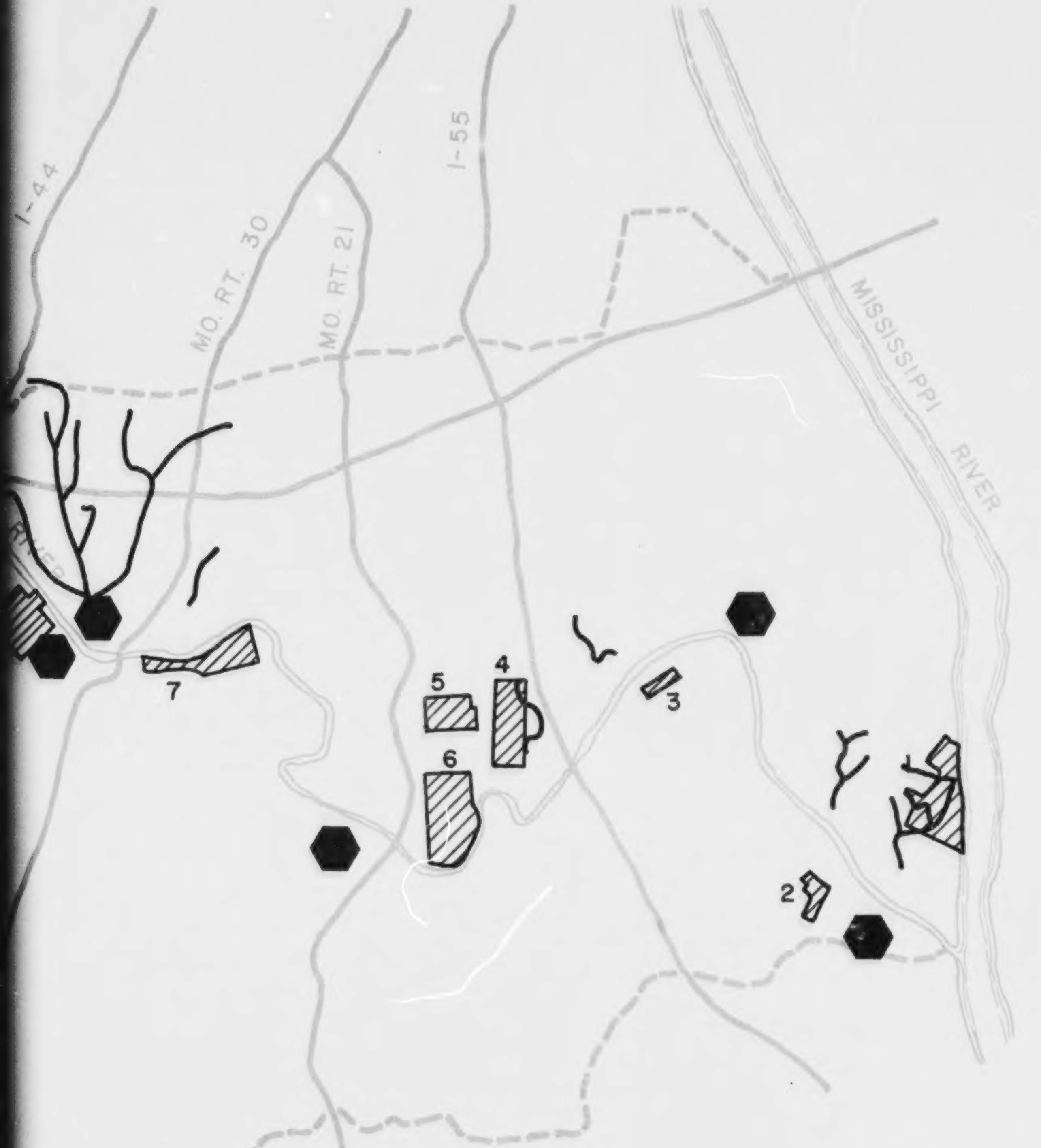
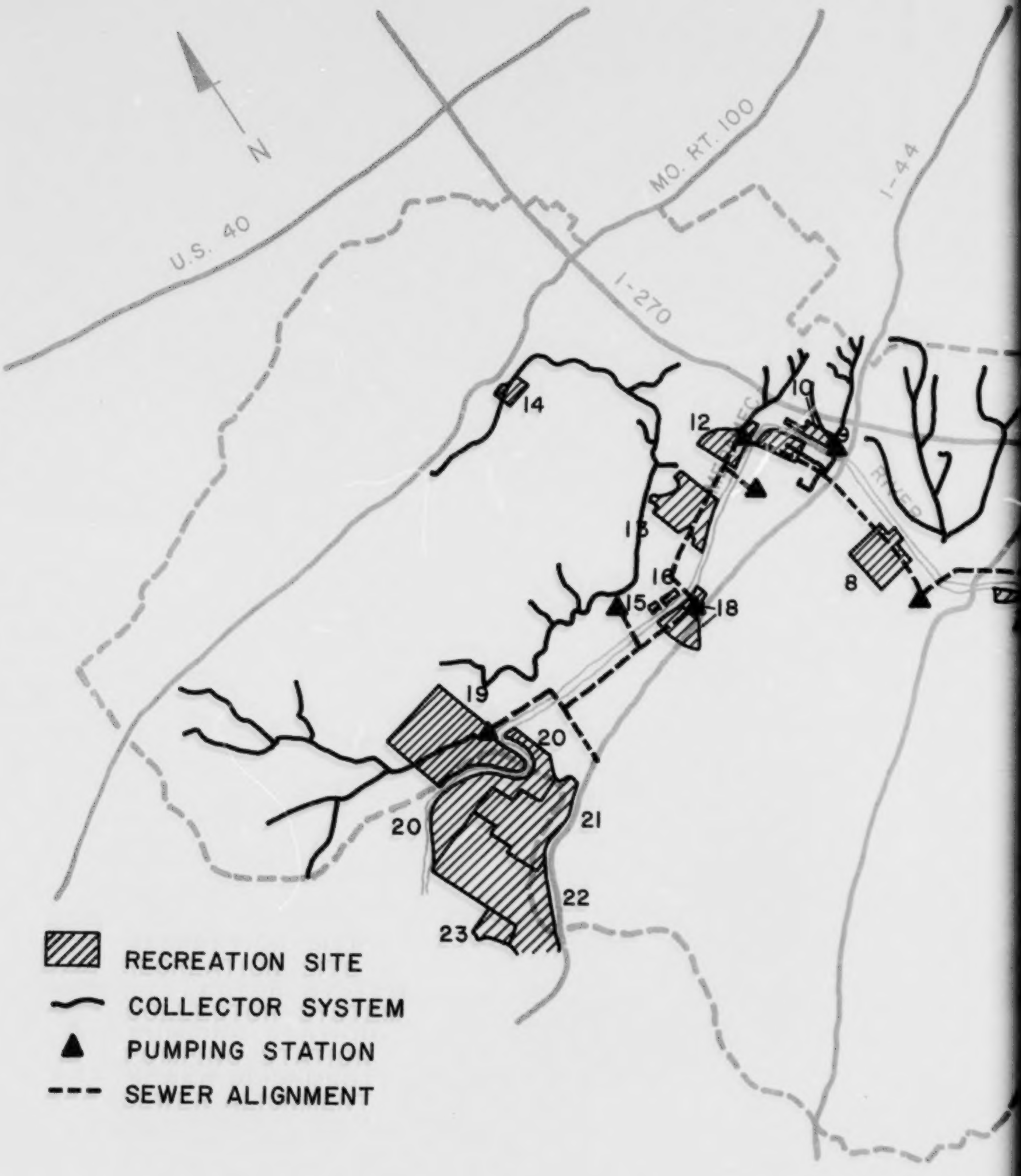

I-44
MO. RT. 30
MO. RT. 21
I-55
MISSISSIPPI RIVER
RIVER
1
2
3
4
5
6
7

FIGURE 73
PRINCIPAL RECREATION SITES
SUBREGIONAL ALTERNATIVE


N
U.S. 40
MO. RT. 100
I-270
I-44
MERAMEC
RIVER
14
12
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16
15
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21
22
23
▨ RECREATION SITE
COLLECTOR SYSTEM
▲ PUMPING STATION
SEWER ALIGNMENT

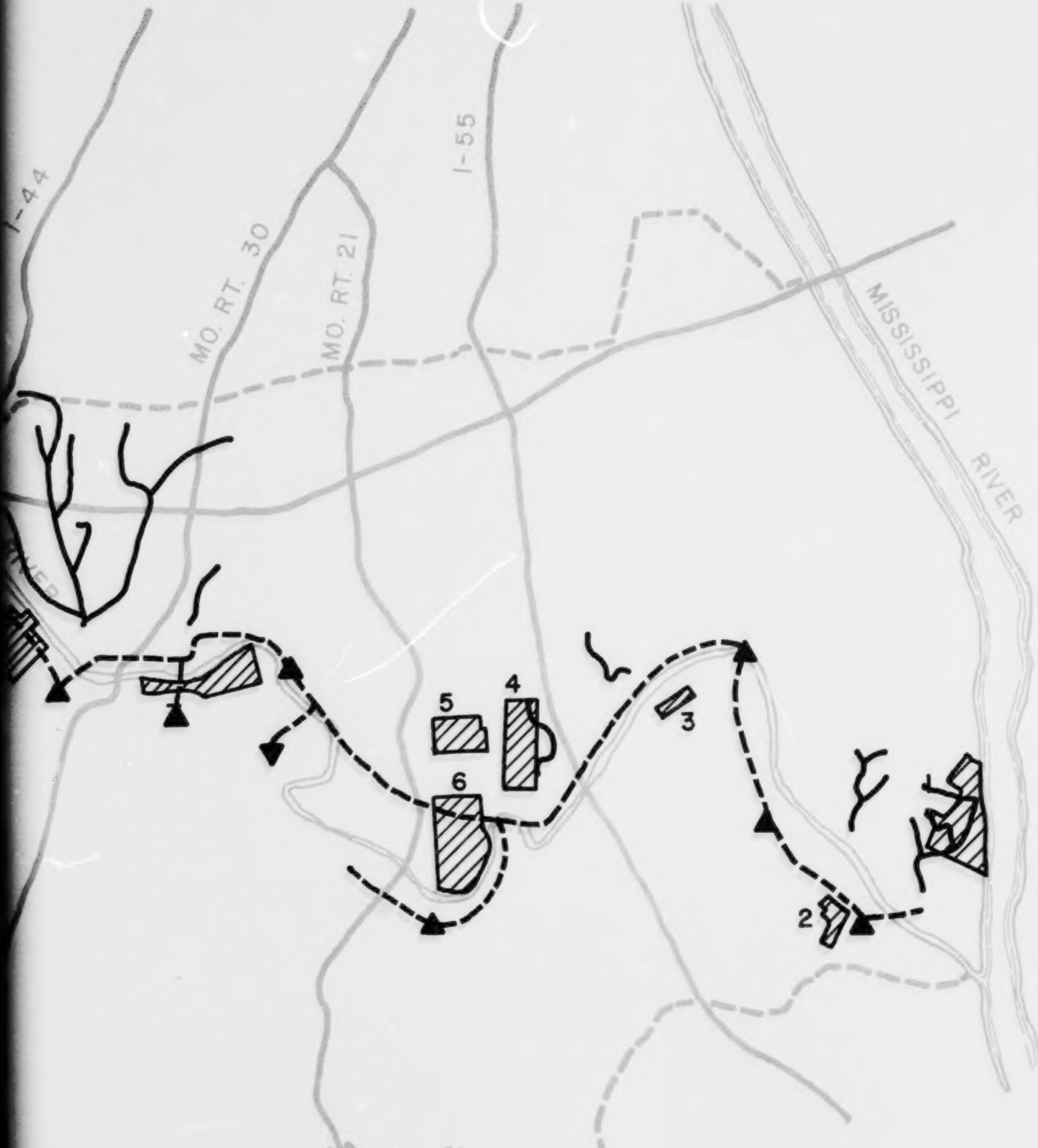
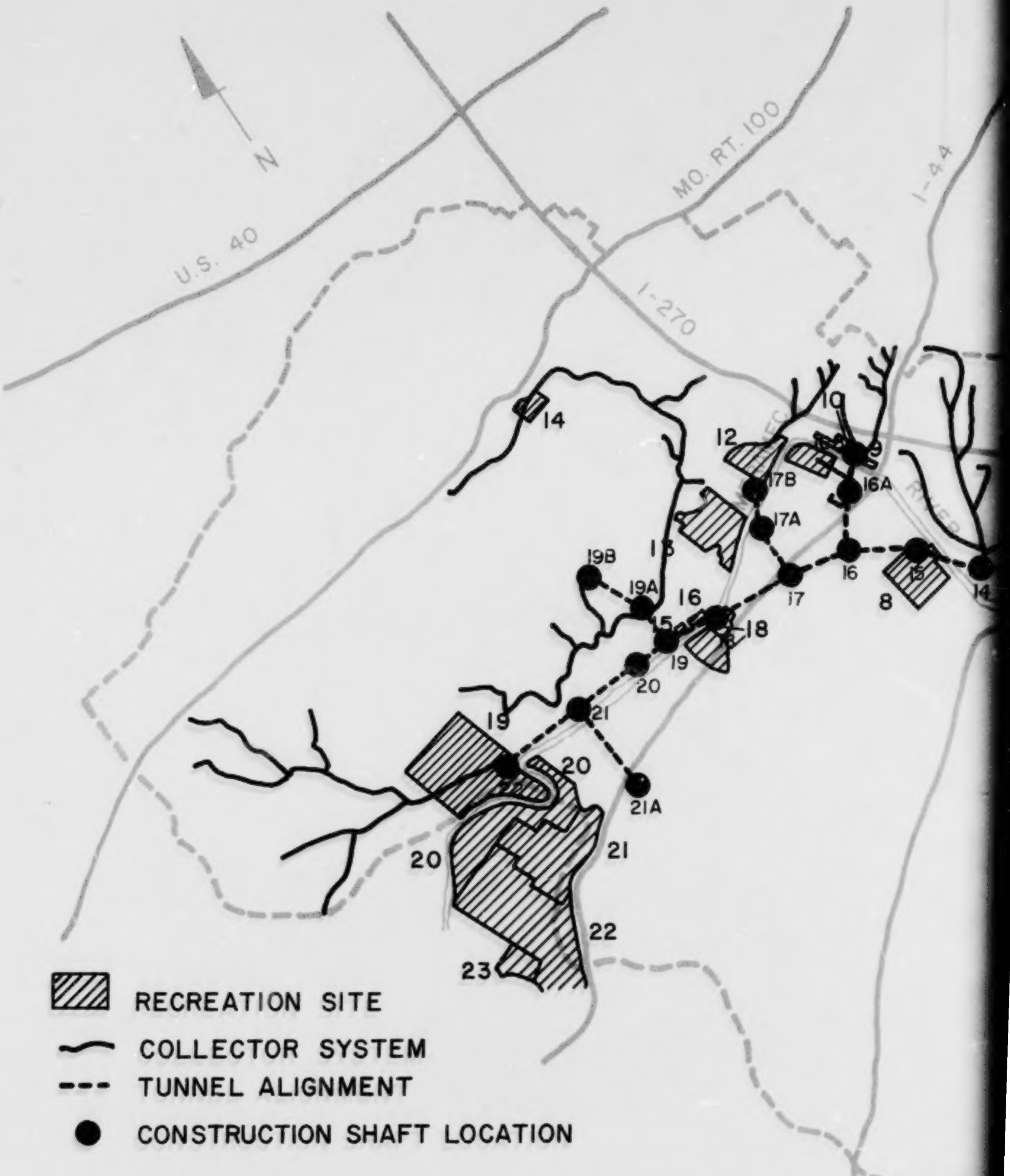

I-44
MO. RT. 30
MO. RT. 21
I-55
MISSISSIPPI RIVER
5
4
3
6
2

FIGURE 74
PRINCIPAL RECREATION SITES
REGIONAL ALTERNATIVE
OPEN CUT CONVEYANCE


N
U.S. 40
MO. RT. 100
I-270
I-44
RIVER
14
12
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16A
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17A
13
19B
19A
16
15
17
16
8
15
14
18
19
20
21
19
20
21A
20
21
22
23
RECREATION SITE
COLLECTOR SYSTEM
TUNNEL ALIGNMENT
CONSTRUCTION SHAFT LOCATION

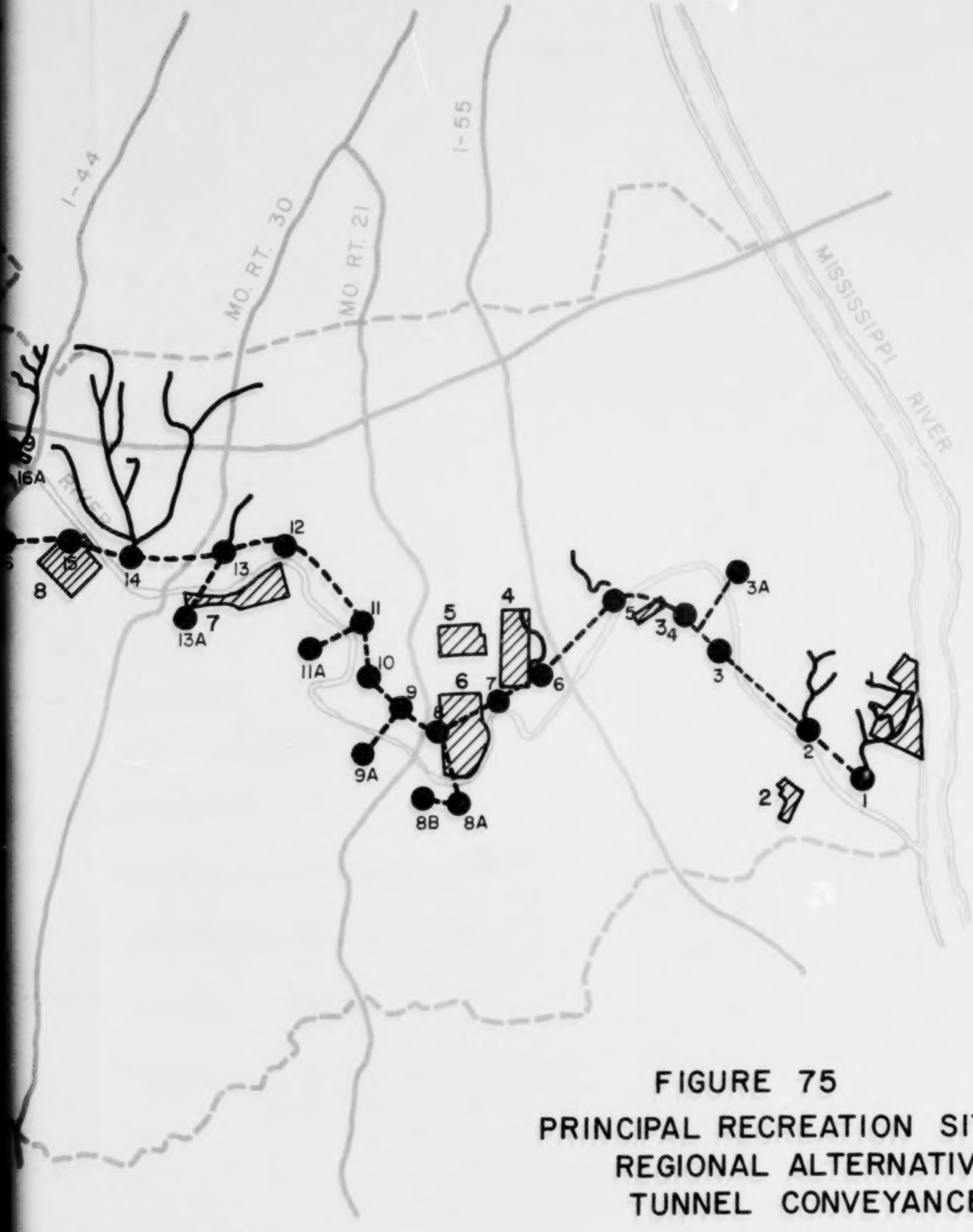
I-44
MO. RT. 30
MO. RT. 21
I-55
MISSISSIPPI RIVER
RIVER
9
16A
16
15
8
14
13
12
7
13A
11
11A
10
9
9A
8
8A
8B
6
7
5
4
6
5
4
3
3A
2
2
1

FIGURE 75
PRINCIPAL RECREATION SITES
REGIONAL ALTERNATIVE
TUNNEL CONVEYANCE

dust, odors, or aesthetic degradation caused by project activities. This decreases in the quality of a recreational experience is, in turn, largely dependent on the participant's perception of the impediments to this enjoyment. Generalized judgments concerning visitor perception of aesthetic impacts involve a great deal of subjectivity by the analyst or planner. However, a sufficient amount of data on visitor perception indicates that the "passive" types of recreation are more dependent upon the relative serenity and aesthetic quality of the recreation environment than are the "active" types of recreation. Therefore, indirect environmental degradation, such as noise, dust and odors, will devalue passive activities more than active recreational activities.

Table 10 in Chapter 3 includes a general description of the types of recreation opportunities offered at parks in proximity to the proposed project area and a determination of whether these opportunities are principally "active" or "passive". While such generalized statements are, admittedly, oversimplifications, they are intended to clarify the types of "perceived impacts" we will be discussing in a substantial part of this section.

In the following paragraphs, recreation areas will be referred to by number as shown in Table 10.

Construction Impacts

As discussed earlier in this report, several new collector lines will be constructed under all three project alternatives (see Figure 31). These collector lines, nearly all of which will be confined to valleys of small streams, will pass through parts of Recreation Areas 1, 4, 9, 10, 11, 12, 14 and 19.

Normal modern engineering construction methods should, however, preclude this construction from having major direct adverse impacts on all of these sites. In Recreation Areas 1, 10, and 11, however, the quality of the passive recreation experience will suffer serious, but short-term, adverse impacts from noise, dust, and aesthetic degradation.

Under the subregional alternative, parts of Recreation Areas 12, 15, and 19 will be adversely affected by construction noise. Areas 12 and 15, however, are largely devoted to sports and games activities, which should not be affected by the noise levels and Area 19 is, as yet, undeveloped.

Under the regional alternative with tunnel conveyance, parts of Recreation Areas 4, 6, and 19 will be directly disturbed by construction shaft placement and will receive noise impacts. Areas 6 and 19 are undeveloped, however, and Area 4 is devoted chiefly to sports activities which would not be interrupted by nearby construction. Area 15, which is also developed for sports and games, will receive higher noise levels than those currently existing, but not high enough to preclude the enjoyable pursuit of the types of activities offered.

Under the regional alternative with open-cut conveyance, Recreation Areas 8, 9, 12, 18, and 19 would receive direct construction impacts. Again, however, the types of recreation offered at these areas would not be seriously affected by short-term construction activities carried out with normal modern engineering practices.

In summation, construction activities associated with all three of the project alternatives could have short-term adverse effects on recreation in the project area. However, most, if not all, of these potential impacts will be sufficiently mitigated by normal construction specifications to preclude serious interference with recreation.

Operational Impacts

While the impacts of construction on recreation differ very little between the alternatives, there is a significant difference in the impacts of operation.

Under the regional alternative with tunnel conveyance, operations will have identifiable adverse impacts on recreation resources. All pumping and treatment will be confined to a single site which will be separated by a considerable distance from recreation areas. Maintenance activities at other points throughout the system will be minimal. A number of sites now occupied by treatment facilities would be made available for other uses, including recreation in some cases.

Under the regional alternative with open-cut conveyance, sewage treatment activities would, again, be confined to a single site. However, five of the 14 pumping stations in operation to aid in flow conveyance will be in direct proximity to Recreation Areas 8, 9, 12, 18, and 19; all of these stations will occupy sites which could be put to other uses. These pumping stations would require regular maintenance.

Nine sewage treatment plants would be in operation under the subregional alternative. Most of these plants could occupy sites at the mouths of tributaries which could be regarded as "strategic" in terms of the Lower Meramec's aesthetic environment. All of these plants would require routine maintenance as well as access and parking areas for plant employees.

Recreation in the project area will benefit from all three alternatives in terms of water quality improvements, and the accompanying public health benefits and improved swimming, fishing, boating and aesthetics.

Secondary Impacts

The relationship between recreation opportunities in the project area and the development which is projected to occur with project implementation is quite complex. Adverse impacts which might result from this development are lowered air quality, increased noise levels, and increased vehicular traffic throughout the project area. The increased development and population could also result in the use of recreation facilities beyond their carrying capacities, which could lead to a decrease in their value as recreational resources. Conversely, the increased development and population in the project area, combined with the improved water quality resulting from the project, could lead to an increased public awareness of the virtues of the project area's recreational resources and enhance public support of the concept of a "Lower Meramec Recreation Area".

IMPACTS ON CULTURAL RESOURCES

As emphasized in Chapter 1, the Introduction to this EIS, one f the principal areas of concern from the inception of this project has been the high probability of impacting cultural resources under various plan routings. In order to minimize unnecessary disturbance of these resources and develop guidelines for future, more detailed, planning of routes, a cultural resource survey of the project area was performed. A summary report of that survey follows.

Data Collection

The contract between Southern Illinois University, Edwardsville and RETA specified a reconnaissance survey of cultural resources (historical, architectural, and archaeological) within the Lower Meramec River Basin with particular emphasis upon areas potentially affected by the construction alternatives.

The purpose of the reconnaissance survey, as defined in the guidelines of the Missouri Department of Natural Resources, is to "provide a general impression of an area's historic properties and their values." This survey involved small scale field work relative to the overall size of the area being studied (116).

The investigations in the project area consisted of:

1) A literature search;

2) A review of the site records of the Missouri Archaeological Survey in Columbia, Missouri;

3) A records check of National Register documents on file at the Missouri Department of Natural Resources, Office of Historic Preservation;

4) Interviews with local residents, collectors, and amateur archaeologists; and

5) A pedestrian survey.

The data collected by the first four methods was used to summarize the known historic, architectural, and archaeological features of the Lower Meramec project area. These data were then checked for accuracy by pedestrian survey if specific known features were located within 100 meters of the proposed construction locations.

A pedestrian survey was then utilized to cover the proposed construction zones throughout the project area in order to locate sites previously unreported. As a general rule, areas of poor to bad surface visibility were walked at 50-meter intervals, while areas of good visibility were walked at 10- to 20-meter intervals.

U. S. Geological Survey 7.5 inch maps were provided by RETA for use in the field. Generalized construction plans were drawn on the maps by RETA and used as a guide to areas to be surveyed. Due to the generalized nature of the plans, it was not possible to walk specific lines or construction areas. Instead, zones along and on both sides of the lines were walked. The pedestrian survey was started on January 2, 1978 and continued until January 11 when heavy snow forced a suspension of field work. Due to the continued snow cover, the survey could not be resumed until March 21 and was not concluded until April 20. The period between January 11 and March 21 was used to complete the literature search, interviews, and records review and to complete the laboratory processing and analysis of material from the initial survey period.

Laboratory analysis and survey reports for the Missouri Archaeological Survey were completed prior to the writing of this report. A final detailed report is presently being prepared and will be submitted in the near future.

Survey Results

As discussed earlier, the generalized construction zones were walked at intervals determined by the degree of surface visibility. Approximately 5 to 10 percent of the area was not walked due to poor conditions. A considerable portion of the area was in poor condition for the survey because it was covered with modern cultural features, forest, or pasture. In addition, many of the agricultural fields had poor visibility because of corn stalks and weed cover.

Prior to the field investigations reported in this EIS, a total of 36 archaeological sites had been recorded within 100 meters of the construction zones. Five of these sites were located within the Williams Creek Archaeological District and are on the National Register of Historic Places. An additional 48 new sites were recorded during the pedestrian survey. Two of these 48 sites are also within the boundaries of the Williams Creek District.

Prehistoric Cultures - As of the end of 1977, a total of 130 prehistoric sites had been reported to the Missouri Archaeological Survey from the Lower Meramec Basin Area. These sites cover the entire chronological range of Midwestern prehistory and history from Early Hunter/Paleo-Indian to Trader-Trapper/Historic. The occupation of the area thus spans a period in excess of 12,000 years of human experience.

Although a total of 84 (36 previously reported and 48 new) sites are present, collections were made from 75 locations. Of the collection units, 54 cannot be assigned to specific cultural or chronological periods due to a lack of diagnostic material.

Twenty-one collection units yielding diagnostic material include evidence of 29 components. These include: one Middle Archaic (5000-3000 B.C.); four Late Archaic (3000-1000 B.C.); three Early Woodland (1000-500 B.C.); seven Middle Woodland (500 B.C.-400 A.D.); twelve Late Woodland (400-900 A.D.); one early Mississippian (900-1450 A.D.); and one possible Late Mississippian (1450-1700 A.D.).

Previous site reports indicate that four of the sites which yielded no diagnostic material include: one Early Archaic; one Middle Archaic; two Late Archaic; one Late Woodland; one Early Mississippian; and one Late Mississippian components. In addition, the previous reports indicate that four of the single component sites collected probably have second components which are identified on the forms as two Forager/Archaic and two Village Farmer/Mississippian components.

The 75 collection units thus include a minimum of 40 identifiable components ranging from Early Archaic to Late Woodland and 50 unidentifiable components.

Only 14 of the 75 collection units yielded ceramics (13 Late Woodland and one Mississippian) and none of the sites yielded more than 17 sherds. The lack of ceramics is somewhat surprising and can only be partially accounted for by surface conditions.

Distribution of Sites - The distribution of sites within the alluvial valleys of the project area appears to be based upon two variables: elevation/relief and water source. In general, sites are located in areas of significant relief such as terraces, ridge swells, or colluvial slopes with elevations between 400 and 435 MSL, and are adjacent to or near secondary water sources such as creeks, intermittent streams, marshes or ponds. Sites are located along the first terrace of the Meramec only in areas which are adjacent to secondary water sources. In addition, the sites within the alluvial valley tend to correlate with soils of the Ashton Association and the Belknap, Bonnie and Nodaway Series. Within the alluvial valley, sites are likely to be found in nearly every location which meets the criterion listed above.

The upper portions of the larger secondary creeks or intermittent stream valleys also yielded sites on colluvial slopes or terraces adjacent to water. Unlike the situation in the alluvial valley, the sites in secondary valleys are few in number, widely scattered, and the occurrence is much less predictable. In large part, the lack of predictability probably results from the paucity of survey data due to the poor visibility. The limited amount of bluffs within the area also were subject to poor visibility and yielded few sites.

Historic and Architectural Sites - Although the Lower Meramec River Basin has been occupied by Europeans since the early 18th century, it contains few historic sites of significance. This is especially true within the 100-meter distance from the areas of construction indicated by the preliminary plans. Within this restricted zone there are no known significant historic sites and only two architecturally significant sites. The architectural sites are located within the Williams Creek Archaeological District and the Central Spring-Branch-Keifer Creek Valley.

Significance of Sites: Although the survey did not yield detailed information on any of the sites sufficient to warrant immediate nomination to the National Register, all sites thus far located should be considered significant. This derives from several factors:

1) No long-term research program has been undertaken in the Lower Meramec Basin area and, consequently, the archaeology is poorly known and even more poorly understood. In such a situation almost any excavation would yield information significant for the understanding of the area.

2) The archaeology of the area is being destroyed at an alarming rate even in the absence of the MSD project. This destruction is primarily residential and industrial and the remaining sites are becoming increasingly important for our understanding of the area's prehistory.

Conclusions

The present generalized nature of the construction plans does not allow the formulation of site-specific statements of probable impact. However, it is clear that the impact of the construction will be directly proportional to the amount of surface disturbance.

Clearly, the regional system involving the open-cut trench will impact a number of archaeological sites. It is highly unlikely that any plan involving the amount of disturbance necessitated by this plan can be sited so as to avoid major archaeological impact. The regional plant near the mouth of the Meramec will almost certainly impact at least two sites.

The regional system utilizing a tunnel trunk line would have considerably less impact upon the archaeology if the tunnel access shafts can be placed in areas of low archaeological potential. This plan also involves the regional plant near the mouth of the Meramec which will impact the same two sites as under the regional alternative with open-cut conveyance.

On the basis of the amount of land disturbance alone, the subregional system appears to be the least likely to cause major archaeological impact, although it is probable that some of the nine subregional plants will involve archaeological sites.

Recommendations

Although the selection of the alternative plan to be implemented will be based on numerous factors in addition to archaeology, we strongly recommend that, on the basis of archaeology, the regional system involving an open-cut trench be avoided. The most attractive plan from the standpoint of archaelogy is the subregional plan, followed closely by the regional alternative with tunnel conveyance.

Following the selection of the system to be implemented, planning of the specific placement of various facilities should involve the following considerations:

1) Avoid as many of the known sites as possible.

2) Either avoid or minimize construction within the boundaries of the Williams Creek Archaeological District. Any plans involving surface disturbance within the District should be coordinated with the Office of Historic Preservation of the Missouri Department of Natural Resources.

3) Attempt to avoid areas of high potential within the alluvial valley. These areas are characterized by: a moderate amount of physiographic relief; a MSL elevation between 410 and 435 feet; and proximity to secondary sources of water. Such areas almost certainly will yield archaeological sites.

4) Within secondary valleys, colluvial slopes and terraces adjacent to water should be avoided. Due to the lack of visibility during the survey we cannot say, with any degree of assurance, how serious the potential problems are likely to be in these areas.

Following the selection of the alternative plan and completion of detailed planning and mapping of all facilities, it will be necessary to implement an extensive archaeological program including:

1) Intensive survey of all areas to be impacted. This should include a program of subsurface investigation in areas of obscured visibility. The subsurface technique recommended is shovel probing or shovel testing at an interval of 10 to 15 meters.

2) Testing of all sites to be directly impacted in order to more fully assess their potential to yield significant data.

3) Movement of facilities to avoid significant sites. Mitigation of such sites through excavation. The decision to move the facilities or mitigate through excavation should be made in cooperation with the Office of Historic Preservation of the Missouri Department of Natural Resources.

FLOODPLAIN IMPACTS

As illustrated on Figures 31 through 33, a significant proportion of the project development under all three of the action alternatives would take place within the 100-year floodplain. (The 100-year or "base" floodplain is defined by the Federal Water Resources Council as the area having one chance in a hundred of being flooded during any 1-year period). While it is recognized that development on the floodplain is not desirable from an environmental standpoint, economic considerations necessitate such development. Development in the floodplain will allow for maximization of gravity flow through the system and eliminate the need for numerous pumping stations, which would be expensive to construct, operate, and maintain. The types and magnitudes of impacts on floodplain resources, and measures to minimize these impacts under the three project alternatives, are discussed in the following paragraphs. The impacts of construction on water quality, biological systems, and other components of the floodplain ecosystems are discussed in detail in subsequent sections of this report.

Subregional Plan

The major development under this plan which would take place in the base floodplain is the construction of the system of collector lines. As mentioned earlier, the location of portions of these lines in floodplain areas is necessitated by the need to maintain gravity flow through the system as much as possible in order to realize significant economic benefits. Since the lines will be constructed so as to minimize infiltration, exfiltration, and inflow, the chief impacts will occur during construction and will consist principally of direct physical disturbance of the floodplain in many of the tributaries. Following construction, disturbed areas will be restored to their origianl condition to the extent practical.

Other development under this plan which would directly affect the floodplain is the construction of at least three, and as many as seven, of the nine sewage treatment plants. Structures involved at these plants would be floodproofed through standard construction procedures and would create or receive only minimal impacts. Lagoons associated with the plants, however, would create more significant problems. In situations where it would not be practical to site lagoons above the floodplain, they would have to be elevated through the use of fill. Since the plants are to be sited near the mouths of tributaries, this landform manipulation could result in significant alterations in flow regimes.

Regional Plan - Open-Cut Construction of Trunk

Four types of activities included in this plan would have adverse effects on floodplain management. The impact of the first type of activity, construction of collector lines, would be nearly identical to the impact of collector construction under the subregional plan. The second activity, construction, floodproofing, and maintenance of pumping stations would result in additional disturbance. Again, the floodplain would be restored to a relatively "natural" state following collector-line construction. The pumping stations would, however, remain as permanent alterations of the floodplain. The third type of activity, construction of the main-trunk tunnel by open-cut construction, would have the most significant adverse effects on the floodplain. This construction would involve disruption of several miles of floodplain and numerous crossings of the Meramec. While the floodplain would be restored to the extent practical following construction, the extensive construction activities involved would have significant impacts on water quality, aquatic organisms, and emergent vegetation. The fourth type of activity which would take place under this plan is the construction of the regional sewage treatment plant near the confluence of the Meramec and the Mississippi. As explained in Chapter 6 of this EIS, the only sites in the study area offering sufficient acreage of topographically suitable, undeveloped land for this treatment plant are located in the Meramec River floodplain. As described in Chapter 6, the treatment plant would be protected from the 100-year Meramec River flood by a combination of structural floodproofing, siting of the main palnt and lagoons at the higher site elevation to minimize flood-protection needs, and placement of structures on an elevated berm. The construction of this berm would require the placement of an estimated 380,000 cubic yards of fill in the floodplain. However, the section of the Meramec involved has long been subjected to backwater flooding from the Mississippi (with accompanying silt deposition) and is not an ecologically sensitive area. The floodplain is of sufficient width in this section to minimize any major hydrologic alterations which could result from the fill placement.

Regional Plan - Tunnel Construction of Trunk

The collector system which would be constructed under this plan would be similar to that constructed for the subregional plan and the alternative regional plan. A single regional plant would be constructed in the same area as described under the other regional plan. No upstream pumping stations would be required. Construction required for this plan which differs from the plans discussed earlier includes trunk-line construction by deep rock tunneling, construction of construction shafts (approximately 30) for tunnel access, and construction of drop shafts connecting the collector lines to the trunk.

The magnitude of the floodplain impacts under this plan would be significantly less than those for the other regional plan and would be comparable to those under the subregional plan, in that construction shaft placement would create additional disturbance of the Meramec itself but no premanent above-ground structures would be required at the mouths of tributaries.

All three alternative plans would accommodate increased growth in the Lower Meramec Basin. It is unlikely, however, that any significant part of this growth will occur in the floodplain or will adversely affect the floodplain's character, due to the following factors:

1) Much of the remaining undeveloped land in the study area floodplain has been acquired or is being acquired by St. Louis County or the State of Missouri for recreational purposes. Development of these lands will be subject to stringent floodplain management regulations set forth by these agencies and by the National Parks Service and/or Bureau of Outdoor Recreation when federal funding is involved.

2) Little land suitable for development remains in the floodplain. A combination of soil characteristics, federal regulations, and the flood-prone character of the area place considerable constraints on further development.

CHAPTER 6

SELECTED ALTERNATIVE

The process used to select the optimal plan for providing sewerage to the project area involved weighing the benefits of each alternative (i.e., the degree to which that alternative produced the desired results) against the economic and environmental costs of that alternative. This process was dependent on the analysis of numerous factors such as predicted environmental impacts, estimated costs, and projection of future development. Factors of principal concern to this project have been discussed in Chapters 4 and 5.

This chapter summarizes the results of analyses developed in those chapters, introduces several considerations not included in previous analyses, and presents the plan for providing sewerage which will result in the greatest overall benefits to the project area, with the least environmental degradation at the lowest economic cost. The order in which project alternatives are considered in this chapter is as follows:

1) Analysis of overall system of collection, conveyance, and treatment

2) Analysis of systems of wastewater treatment

3) Analysis of systems of sludge management

4) Discussion of treatment plant site selection and flood protection alternatives for the treatment plant site.

Descriptions of project phasing, interim treatment facilities, and the environmental impacts of the interim facilities are also included in this chapter.

OVERALL SYSTEMS

As discussed in Chapter 4, the initial screening of numerous system alternatives, which was based on each alternative's ability to provide the required levels of service, engineering feasibility, and cost factors, resulted in the selection of three alternatives for further analysis. These three alternatives, discussed in detail in Chapter 5, are a subregional system, a regional system with main-trunk conveyance constructed by conventional open-cut methods, and a regional system with main-trunk conveyance constructed by deep-rock tunneling.

Chapter 5 also presented comparative analysis of the environmental consequences of implementing each alternative. Table 58 summarizes the results of the Chapter 5 analysis and compares the impacts of the three alternatives in terms of the most significant environmental parameters. In the table, impacts of the alternatives are rated "1" for least impact to "3" for greatest impact. Secondary impacts are assumed to be equal under all three alternatives.

It should be noted that although Table 58 presents a "total score" for each alternative in order to illustrate overall impacts, many of these impacts are not, in reality, of equal importance. The factors which are of greatest significance to this project are construction impacts on water quality, aquatic biota, archaeological resources, recreation facilities and long-term water quality impacts. However, the impact rankings would be the same if a weighting system were applied to indicate this differential "significance". The regional system with tunnel conveyance would still rank "best" (least impact) and the regional system with open-cut conveyance construction would still rank "worst".

In summation, the regional plan with tunnel conveyance is the most acceptable alternative in terms of environmental impacts. In addition, the estimated costs comparison presented at the end of Chapter 4 indicates this alternative is the least expensive of the three. Therefore, the regional plan - tunnel alternative is recommended as the best overall system of collecting, conveying, and treating sewage in the project atea.

SYSTEMS OF WASTEWATER TREATMENT

As discussed in Chapter 4, three general systems of wastewater treatment were screened for applicability to this project: land application, treatment and re-use, and treatment and discharge to receiving waters. The first was eliminated because of 1) the lack of suitable land in the project area, 2) jurisdictional and transport problems in using land outside the project area, and 3) the extended periods of colder weather in the area which would require a capacity for the storage of large volumes of wastewater. The second system, treatment and re-use, was rejected because the project area's plentiful water supply made the polishing treatment, which would be necessary for re-use, economically unjustifiable. The third method, treatment and discharge to receiving waters, was the method chosen. The stream selected to receive the effluent is the Mississippi River. The principal reasons for this choice, all of which have been discussed more fully in previous chapters, are:

TABLE 58

RANKING OF IMPACTS UNDER ALTERNATE TOTAL SYSTEMS(a)

Impacts	Subregional	Regional-Open-Cut	Regional-Tunnel
Noise Environment:			
Construction	1	3	2
Operation	2	3	1
Air Quality:			
Construction	1	3	2
Operation	3	2	1
Water Quality:			
Construction	2	3	1
Operation	3	2(b)	1(b)
Geology/Groundwater:			
Construction	1	3	2
Operation	-	-	-
Terrestrial Biota:			
Construction	1	3	2
Operation	3	2	1
Aquatic Biota:			
Construction	1	3	2
Operation	3	2	1
Archaeologic Resources	1	3	2
Primary Land Use	2	3	1
Recreation:			
Construction	1	3	2
Primary	2	3	1
TOTAL	27	41	22

Notes: (a) "1" indicates least impact; "3" indicates greatest impact.

(b) Regional-open-cut favored for ease of maintenance and superior control of emergencies.

1) The Mississippi has a higher flow rate and a greater ability, subsequently, to assimilate pollutants without serious water-quality degradation than does the Meramec,

2) A less stringent stream classification (in terms of discharge of pollutants) applies to the Mississippi than to the Meramec,

3) Use of the Mississippi as a receiving stream would eliminate discharges directly upstream from public water-supply intakes, which would not be the case when discharging to the Meramec.

Wastewater discharged to the Mississippi could receive a lower level of treatment than could wastewater discharged to the Meramec without serious environmental degradation and with considerable economic savings.

A review of the effluent quality requirements for the Mississippi River indicates that conventional secondary treatment of wastewaters will be adequate to meet discharge requirements. Twelve common methods of secondary treatment were investigated in terms of the environmental, economic, and practical considerations discussed in Chapter 4.

Four methods ranked nearly equal in this investigation, all of which are of the activated sludge process of biological aerobic waste treatment. These four methods are: conventional air activated sludge with tapered aeration; conventional air activated sludge with step aeration; complete mix air activated sludge; and, high purity oxygen activated sludge. These four methods were subjected to further analysis which indicated that, while all four would produce acceptable treatment levels and would cost nearly the same, the step aeration process had significant advantages over the other three methods in its practical applicability to the project. Its major advantages were it had the lowest maintenance costs, had the least technically-involved operation, and had the greatest similarity to MSD's existing facilities, making the inclusion of plant operation and maintenance procedures the simplest to integrate into MSD's overall program. Activated sludge processing with step aeration was, therefore, selected as the best wastewater treatment method for the project.

SYSTEMS OF SLUDGE MANAGEMENT

Sludge is a broad term used to indicate a variety of aqueous suspensions produced as by-products of wastewater treatment processes. The volume and character of sludge produced depends on the composition of the wastewater treated and the efficiency of the treatment process. The solids portion of sludge is largely composed of the substances responsible for the offensive characteristics of raw sewage. Given a certain type and strength of wastes to be treated, the most efficient wastewater treatment process will produce the greatest volume of sludge. Based on this relationship, it is apparent that effective wastewater treatment requires the treatment and disposal of relatively large volumes of sludge. In addition to the offensive characteristics of sludge, sludge disposal is further complicated because a large proportion of sludge is moisture (thus increasing volumes to be managed) and the portion of sludge produced by biological treatment takes the form of organic matter (synthesized by the process), which is readily decomposed into offensive materials.

Sludge Processing and Disposal

Due to the characteristics of sludge discussed above, the primary purposes of sludge processing are reduction of volume and destruction of offensive components. The level of treatment necessary to render sludge suitable for environmentally-acceptable disposal is largely dependent on the disposal method selected. Therefore, alternate methods of disposal will be discussed in this section to provide a realistic context for subsequent discussion of sludge processing alternatives.

Five alternate sludge disposal techniques were considered for this project: land application, land reclamation, sanitary landfilling, use for power generation, and lagooning. The first two alternatives were eliminated from further consideration for several of the same reasons which led to the rejection of wastewater treatment by land application; that is the unsuitable soil and/or topographic characteristics of available lands in the project area, political problems involved in disposal outside the area, and the potential for groundwater contamination. One option within the land application category, stabilizing, drying, and marketing sludge as a soil conditioner, was not considered to be economically feasible because of the small scale that would be involved in the project.

Sanitary landfilling of the sludge was eliminated as an alternative because studies of solid-waste disposal practices in the St. Louis area indicate: 1) many of the area's landfills are approaching the end of their useful lives, and 2) recommendations have been made that landfilling operations be phased out of the area's solid waste disposal program.

Two options for the use of sludge for power generation were considered. The first, use of sludge for generation of power for the treatment facility itself, was eliminated because the costs involved in constructing a facility to generate power from the relatively small amounts of sludge involved could not be economically justified. The second concept, combining sludge with shredded refuse for incineration by a public utility, was deemed to have considerable merit. In fact, a large-scale project for the burning of refuse in one of the Union Electric Company's power plants has been proposed as the ultimate conceptual solution to the St. Louis area's solid waste disposal problem. However, recent developments in the process of attempting to implement this disposal strategy have demonstrated that it will be very difficult to establish this strategy into a workable solid waste plan for the area. This concept was therefore eliminated from further consideration as a sludge disposal alternative.

If, at some future time, this strategy is implemented, disposal of sludge by incineration should be reconsidered.

The remaining alternative, lagooning of sludge, is not really a means of ultimate disposal since, while lagoons can be sized to hold many years' sludge without requiring large amounts of land, they would eventually need to be cleaned out or abandoned. The technique of lagooning is, however, quite compatible with land application or reclamation as an ultimate disposal means. Lagooning would provide sufficient time for the sludge to become stabilized and to give off excess nitrogen to the air. In addition, sludge could be removed from the lagoons at the time of year most favorable for land application and in amounts suitable for the acreage of land available. Disposal by lagooning must, however, be accomplished with care in order to avoid groundwater contamination, production of nuisance odors and insect populations, and surface water contamination by flooding. These potential problems can be minimized by proper sealing, continuous low-level chlorination, regular mowing of the shoreline, and proper siting or construction of flood-protection devices.

Because of the problems predicted with the other disposal methods considered and the lack of serious obstacles to the implementation of a successful lagooning program, sludge disposal by lagooning is recommended for this project. An investigation of the economic, technical, and operational aspects of on-site versus off-site lagooning, which was carried out in the planning process, indicated on-site lagooning to be the most favorable choice (096).

It was decided that, in order to avoid some of the potential problems associated with lagooning of sludge, the sludge to be lagooned should, at least, be stabilized and partially reduced prior to disposal. The following discussion presents the screening process used to select the optimum process for stabilization and reduction of sludge.

Six general categories of processes for sludge treatment were investigated for this project. These processes are:

1) Thickening or reduction of sludge volume by increasing the concentration of solids in the sludge

2) Stabilization or conversion of sludge into a more readily dewatered form with less offensive characteristics (pathogens, odors, etc.)

3) Conditioning or pre-treatment of sludge to facilitate one of the other treatment processes, such as dewatering

4) Dewatering or removal of sufficient moisture to convert the form of the sludge from an aqueous suspension to a damp solid

5) Heat drying or conversion of the sludge to a relatively free-flowing drier form through application of heat

6) Reduction or any process which would significantly decrease sludge solids volume, usually involving reduction of volatile solids

The last three process categories were eliminated in the initial screening process for the following reasons:

1) Sludge reduction processes aimed at significantly decreasing sludge volume by reducing volatile solids are complicated and expensive. These processes are unwarranted for the project since lagooning was the disposal method chosen and relatively small amounts of sludge would be produced at the Meramec facility.

2) Sludge dewatering processes were not considered necessary due to the small amounts of sludge produced and the fact that the lagooning process is a moderately effective dewatering technique.

3) Heat drying is expensive and consumes relatively large amounts of energy. Again, the relatively small amounts of sludge involved and the choice of lagoon disposal make this process unnecessary.

Six methods of sludge stabilization were evaluated for project application; chlorine oxidation, lime treatment, aerobic digestion, anaerobic digestion, composting, and heat treatment. Screening began with the development of a matrix system similiar to that used for evaluating wastewater treatment processes earlier in this chapter. This involved ranking the six methods in terms of a number of significant factors including cost, operational considerations, and environmental constraints. The three methods which ranked highest were aerobic digestion, anaerobic digestion, and lime treatment. Lime treatment was eliminated because it would 1) interfere with the operation of disposal lagoons, and 2) result in virtually no reduction of organics, thus (considering the lime added) yielding a significantly greater amount of sludge for disposal compared to the other two remaining processes. Aerobic digestion was eliminated because it is unsuitable for stabilizing the types of mixed primary and secondary sludges which would be produced by this project. A detailed examination of anaerobic digestion indicated it is the optimum sludge stabilization method for the project.

Three sludge thickening procedures were evaluated using a matrix system as described above and in terms of their abilities to produce sludge with the optimum consistency for subsequent processing by anaerobic digestion and lagooning. The three methods are gravity thickening, centrifugation and dissolved air flotation. Dissolved air flotation rated "best" on the matrix. Centrifugation rated "worst" chiefly because of the high cost of the method. Gravity thickening was eliminated because the cost of thickening equipment would not be offset by a sufficient reduction in the size, and cost, of sludge processing equipment. Solids would not be concentrated enough to sufficiently reduce the size of sludge processing equipment.

Centrifugation, on the other hand, is capable of producing much higher concentrations of solids than are necessary for subsequent treatment, but at high costs in energy and capital expenditures. Dissolved air flotation is the method recommended because it can produce solids concentrated enough to save considerably on equipment used for subsequent processing without incurring costs greater than these savings.

Finally, three methods of conditioning or pretreating the sludge, which increases the efficiency of treatment by dissolved air flotation, anaerobic digestion, and lagooning, were evaluated. The first method, heat treatment, was eliminated due to its complexity and expense. The second method, elutriation, which is basically a washing technique which reduces soluble carbonate and fine solids content to facilitate separation in subsequent processes, is of real value as a pretreatment with a variety of chemicals, is cheaper, more flexible in terms of operation, and requires less energy than the other two methods. It was further determined that all necessary pretreatment could be carried out by chemical addition, without interfering with subsequent processing. Chemical conditioning is, therefore, recommended for this project.

TREATMENT PLANT SITE SELECTION AND FLOOD PROTECTION ALTERNATIVES

The basic site requirements for the project treatment plant are a minimum of 15 acres for tanks and buildings and a minimum of 20 acres for lagoons. Ideally, the site should be gently-sloping for economy of operation. This type of topography would make it possible to design the plant so that flow through successive units would be carried out by gravity, while multiple tanks performing a common function could be situated in parallel at equal elevations to eliminate the need for complicated flow control devices. It is also desirable for the plant to be sited as far away from incompatible land uses as possible. The only sites in the Lower Meramec Basin offering sufficient acreage of gently-sloping, undeveloped land are located in the Meramec River floodplain.

The site selected offers the aforementioned characteristics along with the additional advantage of proximity to the Mississippi River (the receiving stream). It is located on the eastern edge of the floodplain adjacent to Union Electric's Meramec Power Plant. The site is presently in agricultural use and the recommended plan would remove approximately 60 acres from production. One residence would have to be moved and two others would probably suffer from proximity effects. The existing aesthetic and acoustic environments of the site area are strongly influenced by the presence and operation of the Union Electric plant, so that adverse effects that project implementation would have on this area would be minimal. The site is located approximately 1,000 feet from the Meramec River and is not visible from the River at normal stages.

The site will require protection from the 100-year Meramec River flood level. In addition to siting the main plant and lagoons at the highest site elevations to minimize flood protection requirements, two structural methods of flood protection were investigated. These two methods are protection by a perimeter dike and placement of all structures on an elevated berm. The analysis of these alternative methods included consideration of numerous technical (hydraulic, hydrologic, operational) aspects which are discussed in detail in the facilities plan. A comparison of the basic requirements for the two methods is given in Table 59.

The berm alternative is recommeded on the basis of: 1) increased reliability, since no effluent pumping would be required; 2) elimination of underseepage and reduction of peak flow through provision of gravity stormwater site drainage; 3) the economic advantages of using waste incinerator ash from MSD's LeMay plant and Union Electric's Meramec Power Plant for berm construction; and 4) slightly lower costs on a present worth basis.

TABLE 59

COMPARISON OF FLOOD-PROTECTION ALTERNATIVES FOR MAIN PLANT

Perimeter Dike	Elevated Berm
90,000 cubic yards of compacted embankment required, available from lagoon construction; 20,000 additional cubic yards needed for site leveling	380,000 cubic yards of embankment required; waste ash from MSD incinerator available
Effluent pumping required; peak flows must accomodate site storm drainage	Effluent pumping not required; site storm drainage will not enter system
$3,550,000 present worth cost	$3,340,000 present worth cost

Table 60 summarizes major features of the selected alternative.

PROJECT PHASING AND INTERIM WASTEWATER MANAGEMENT

The recommended project will take 8 to 10 years to complete. As a result, satisfactory sewer service to all parts of the project area can not be provided during this period. In recognition of this fact, the implementation plan for the project was designed to: 1) provide interim collection, conveyance, and treatment facilities where needed, and 2) provide improved service first to those areas having the greatest need for upgrading, such as Mattese Creek, Grand Glaize Creek, Fishpot Creek, and the City of Arnold.

TABLE 60

SELECTED ALTERNATIVE - SUMMARY

Overall System Approach	Regional with conveyance by tunnelled interceptor
Wastewater Treatment	Single biological treatment plant; activated sludge process with step aeration; discharge to the Mississippi.
Sludge Management	On-site; dissolved air floatation thickening of waste secondary sludge; anaerobic digestion of combined primary and thickened secondary sludges; disposal to sludge dewatering lagoons.
Flood Protection	Elevated berm

The tunnel conveyance system will be constructed in phases, beginning at the regional plant and progressing upstream, thus allowing each watershed to connect to the regional system as soon as the main trunk "reaches" that watershed. The regional plant will be constructed with a modular design allowing for phased expansion as watersheds are connected to the system.

Table 61 presents a summary of the project implementation plan, and indicates the major features of each watershed in terms of the four general project phases. The time interval from the beginning of project construction to completion of these phases is estimated to be approximately 3 to 4 years for Phase 1, 4 to 6 years for Phase 2, 5 to 7 years for Phase 3, and 7 to 10 years for Phase 4.

Impacts of Plan

All the components of the plan which will be integrated into the completed project have been discussed in previous sections of this report. These components include the main trunk conveyance tunnel, the subwatershed collectors, and the regional treatment plant. This section is restricted to components functioning as interim facilities.

Construction Impacts - While activities carried out during the construction of interim facilities will undoubtedly result in the creation of some localized noise, dust, and erosion, construction impacts will be minimal for the following reasons:

1) With one exception, all interim facilities will be constructed at sites of existing facilities. The sole exception is a lift station in Meramec Subarea 3 which will be constructed on the site of a proposed tunnel drop shaft. Thus, all construction (other than the lift station) will be carried out at sites which previously have been disturbed, which have already been leveled where necessary, and which are controlled environments, in a biological sense (i.e., subjected to vegetative management and drainage control).

2) Heavy construction such as excavation and paving will be minimal in extent.

3) Most construction will be carried out at sites which are not in close proximity to residences or other sensitive, developed uses.

TABLE 61

PROJECT IMPLEMENTATION PLAN BY SUBWATERSHED[a]

Subwatershed	Phase 1	Phase 2	Phase 3	Phase 4
Meramec Subwatershed 8	Connect to regional plant			
Mattese Creek	Upgrade existing sewage treatment plant and lift station with interim facilities - new trunk lines	Phase out interim; connect to tunnel interceptor		
Meramec Subwatershed 7	Interim upgrade of 2 sewage treatment plants and pumps; new trunk lines	Phase out interim; connect to tunnel		
Fenton Creek	Interim expansion of sewage treatment plant	New trunk lines; phase out interim; connect to tunnel		
Yarnell Creek	Interim upgrade of lift station		New trunk lines; phase out interim; connect to tunnel	
Meramec Subwatersheds 3,4,6	Interim upgrade of lift stations; partial new trunk and eliminate two existing sewage treatment plants in Subwatershed 4		New trunk lines; phase out interim; connect to tunnel	
Meramec Subwatershed 5	No interim		New trunk lines; connect to tunnel	
Grand Glaize Creek	Upgrade five lift stations; new trunk lines to remove discharges from upper reaches; upgrade sewage treatment plant with interim facilities	Additional trunk lines; phase out two lift stations, and one sewage treatment plant	Additional trunk lines; phase out three lift stations	Phase out interim sewage treatment system; connect to tunnel
Fishpot Creek and Meramec Subwatershed 1	Expand existing sewage treatment plant with interim facilities		New trunk lines	Phase out interim sewage system plant; connect to tunnel
Keifer Creek	No interim			New trunk lines; phase out four existing lift stations; two existing sewage treatment plants, connect to tunnel

TABLE 61

PROJECT IMPLEMENTATION PLAN BY SUBWATERSHED[a]

(Continued)

Subwatershed	Phase 1	Phase 2	Phase 3	Phase 4
Williams Creek (St. Louis County)				New trunk lines connect to tunnel
City of Arnold	Upgrade and expand sewage treatment plant with interim facility.	Regional treatment by service arrangement - timing depends on cooperative agreement between Arnold and MSD.		
Remainder of Jefferson County	Treatment by service arrangement - timing depends on designation of authority and cooperative agreement between that authority and MSD.			
	Tunnel interceptor to I-55	Tunnel interceptor to Route 30	Tunnel interceptor to Hwy 141	Tunnel interceptor completed
	First 10 MGD module at regional sewage treatment plant	Second 10 MGD module at regional sewage treatment plant	Third 10 MGD module at regional sewage treatment plant	Final 10 MGD module at regional sewage treatment plant

NOTE: [a] Subwatersheds are shown on Figure 1.

Impacts of Operation - As discussed above, since the project will be implemented over an 8 to 10 year period, fully satisfactory service to the project area will be delayed. As a result, many of the project's benefits will be delayed which will result, to some degree, in the continuation of existing problems. If existing conditions are used as a base, however, the implementation plan clearly results in a series of incremental improvements to water quality, with accompanying decreases in groundwater pollution.

The chief benefits of the plan, in this regard, are:

1) Removal of discharges from the upper reaches of losing streams as collector systems are consolidated and sewage routed to treatment plants in the lower reaches.

2) Decreases in the probability and frequency of lift station overflows as these facilities are upgraded and, finally, eliminated. Telemetric monitoring devices are included in upgrading plans for these facilities. This monitoring will yield quick and accurate indications of emergencies which occur, thus increasing the effectiveness of corrective procedures.

3) Removal of upper reach discharges and decreased overflows will significantly assist in the control of groundwater pollution.

4) The phasing out of facilities which currently occupy land which could be used for other purposes is planned, thus permitting the setting of a rough timetable for developing plans for other uses of the land. Possible uses of this land vary with surrounding land uses. Several parcels are in primarily agricultural areas and land could simply revert to that use. Others are proximate to municipalities or existing parks. These could be acquired for recreation use through coordination between MSD and the appropriate municipal, county, or state authorities.

5) The phasing plan provides service to those areas most in need of service first and to relatively undeveloped areas last, thereby providing service on an as-needed basis.

6) Phasing of the project provides time for residents of less populated upstream areas to organize a system through which the local share of costs can be met.

CHAPTER 7

UNAVOIDABLE IMPACTS

Measures for mitigating adverse project effects were discussed in Chapter 5. Chief among these mitigative measures are construction specifications designed to decrease noise, restrict the extent of surface disturbance in sensitive areas, and provide for consideration of archaeological, biological and recreation resources.

Unavoidable impacts are herein considered to be predicted adverse impacts of project implementation which cannot be eliminated through the application of further mitigative measures. Secondary impacts which cannot be controlled through modifications in project plans are included under this definition.

SECONDARY IMPACTS

The secondary impacts predicted under the proposed project will probably result from changes in land use and increased development. These changes cannot be avoided or controlled through any project action and are, hence, included herein as unavoidable. In reality, however, nearly all of these secondary impacts could be mitigated through the implementation of regulatory measures by the appropriate authorities. These measures include the implementation of plans and zoning ordinances, control of nonpoint water pollution, implementation of an Air Quality Maintenance Plan, and increased control of vehicular emissions. Under the broad interpretation discussed above, unavoidable secondary adverse impacts of the project may be summarized as follows:

1) Increased ambient noise levels accompanying increases in density of development and vehicular traffic

2) Decrease in air quality accompanying development and increased traffic

3) Increased urban storm runoff and subsequent addition of increased hydrocarbons and phenols to project area waters

4) Increased pressures on other public services in the project area

5) Increased pressures on the area's biological and archaeological resources including the loss of terrestrial biological habitat and some archaeological resources during development

6) An increase in taxes to individuals now living in the project area for services to support the projected increase in population. The additional population projected to accompany the proposed improvements will require an increase in public support services such as schools, fire and police protection, utility services, and medical facilities. The provision of these services will probably result in an increase in taxes to those individuals now living in the project area. The extent of this increase is dependent on age-group composition and income characteristics of future residents, methods of financing (i.e., costs borne locally, federal grants, interest rates, etc.), and numerous other factors and, therefore, cannot be accurately predicted. The increases will also be partially offset by the increased tax base which will result from development as well as the increase in individual property values accompanying "new or improved" services. It should also be considered that the provision of new services, such as health care facilities, will result in benefits to the existing populace. The cost of these facilities could be prohibitive under the existing tax base.

PRIMARY IMPACTS

Primary adverse impacts of the project which cannot be completely mitigated are as follows:

1) Pre-emption of land for the sewage treatment plant, sludge-disposal lagoons, and permanent access shafts

2) Terrain disturbance during construction, with accompanying loss of biological habitat, increased erosion and siltation, and aesthetic degradation

3) Short-term construction noise impacts to some residents and in some recreational areas

4) Some interruption of recreation pursuits during construction carried out in recreation areas

5) Increased truck traffic on some minor routes during construction

6) Environmental and economic resources which would be committed to the project

CHAPTER 8

LOCAL SHORT-TERM USES OF THE ENVIRONMENT VS. MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The benefits and the adverse impacts associated with project implementation have been discussed in previous sections of this EIS. They are briefly presented in Table 62 in juxtaposition to one another for the purpose of weighing what might be termed the costs and benefits of the project. As illustrated by this table, numerous tradeoffs between adverse impacts and desired benefits must be considered in evaluating the project's relative merits. This evaluation is further complicated by the fact that many of these costs and benefits are subject to qualification.

Predicting the extent and severity of secondary impacts, for example, is extremely difficult since these impacts interrelate with possible decisions totally outside the control of project planners. However, predictions of the proposed plan's effectiveness in fulfilling its primary purpose, upgrading water quality in the project area, have a sound basis in the water-quality modeling carried out for this study and for the 208 Plan. Both this EIS and the 208 study present forecasts of water quality conditions for the year 2000.

As discussed in Chapter 5, loadings from point and nonpoint sources were determined from population and land use projections developed by the East-West Gateway Coordinating Council. Forecasts were carried out through the use of two water quality simulation computer programs. The two programs accounted for all projected sources of pollution and simulated biological, physical, and chemical processes occurring in the aquatic environment.

The water quality section of Chapter 5 of this EIS presents results of these modeling programs in the form of a comparison of predicted water quality under three major project options - no action (existing treatment), subregional treatment, and regional treatment. The comparison clearly indicates the superiority of the regional system for providing an acceptable quality of water for the project area under existing levels of nonpoint source control. The 208 study assumed that a regional treatment system would be implemented. The study used the same data base in evaluating water quality as was used in this EIS.

The 208 study presents a comparison of the water quality predicted under three alternate levels of point/nonpoint pollution control for the year 2000. A summary of this comparison is

TABLE 62
LONG-TERM VS SHORT-TERM IMPACTS

Parameter	Short-Term Beneficial	Short-Term Adverse	Long-Term Beneficial	Long-Term Adverse
Surface Water Quality	Incremental improvements in tributary streams and better control of overflows throughout phased upgrading.	Localized siltation, increase in turbidity, and changes in ion concentrations accompany construction.	All point discharges removed from tributaries. No point discharges above water-supply intakes. Significant improvements to main stem under all flow conditions, overflows minimized. Monitoring facilitated.	Increased urban non-point pollution accompanying projected urban development with existing controls.
Geology/ Groundwater Quality	Incremental improvements during phased upgrading. Better control of overflows.	Physical disturbance and localized lowering of water table during construction.	Elimination of discharges to groundwater system. Minimization of overflows. Reduction of infiltration and inflow.	Increased disturbance and urban runoff accompanying projected development.
Air Quality	Localized improvements as existing plants phased out.	Localized increases in particulates during construction.	Localized improvements due to elimination of numerous treatment plants.	Suspended particulates, sulfur dioxide, hydrocarbons accruing to projected development predicted to exceed standards under existing low-density areas.
Terrestrial Biota		Direct disturbance of approximately 100 acres of habitat. Potential disturbance of endangered species.	Potential additional habitat as existing facilities phased out.	Up to 6,000 acres of radical habitat alteration accompanying projected development.
Aquatic Biota	Incremental improvements in upstream tributary breeding areas during phased upgrading.	Localized adverse effects on filter-feeding organisms and breeding of population during construction.	Significant benefits in direct proportion to water-quality improvements.	Adverse effects of phenols, hydrocarbons in urban runoff accompanying projected development with existing controls.
Land Use		Disruption of other uses during construction.	Sites of existing facilities made available for other uses. Improved service allows for development.	Sixty acres of agricultural land and one residential plot pre-empted for treatment plant. Any adverse effects of projected development.
Cultural Resources			Knowledge of projected area's cultural resources furthered by project survey.	Possible disturbance of archaeological resources.

TABLE 62

LONG-TERM VS SHORT TERM IMPACTS
(Continued)

Parameter	Short-Term Beneficial	Short-Term Adverse	Long-Term Beneficial	Long-Term Adverse
Recreation		Minor disruption of activities and lowering of quality of recreation experience during construction.	All existing upstream sewage facilities removed from proximity to recreation uses. Potential use of sites of existing facilities for recreation. Improvement in quality of surface waters with significant benefits to recreation.	Increased pressures on recreation areas accompanying projected development.
Public Health and Safety	Increment improvements to water quality throughout phased upgrading.	Construction hazards to workers - slight danger to public during excavation. Localized air quality impacts during construction.	Elimination of point discharges upstream from water-supply intakes. Bacteriologically safer waters for recreation.	Adverse effects of projected urbanization.
Economics	Construction employment. Increased treatment efficiency incrementally during phasing.	Disruption of other uses during construction. Initial construction costs and resources used in construction.	Increased treatment efficiency. Economic benefits accruing to secondary development. Sites of existing facilities made available for other uses.	Non-renewable resources committed to project. Continuing costs of operation and maintenance of facilities. Sixty acres pre-empted for regional facility. Costs of other public services to support projected development.

presented here to indicate the long-term effects of this project on water quality, in terms of the aforementioned decisions outside the control of the project. The 208 comparison was developed as follows:

1) Four sets of possible pollution control conditions for the project area were examined: 1) present levels of control (existing), 2) secondary point-source treatment/existing nonpoint control practices (level 1); 3) sufficient control of both point and nonpoint sources to meet proposed state standards and stream-use goals (level 2); and, 4) more stringent controls to meet 208 water quality goals (level 3), which are more stringent than proposed state standards due to a projected reclassification of many stream-uses.

2) Water quality predicted under the four sets of conditions was rated in terms of its ability to meet 208 standards for ammonia, coliform bacteria, phosphates, oil and grease, and phenols. Ratings given were: poor for those conditions under which levels of one or more of the above pollutants are predicted to exceed 208 standards on a regular basis; fair for conditions under which all standards would be met, except for under 10-year low-flow conditions; and, good for conditions under which 208 standards can be expected to be met at any given time. Table 63 presents the results of this comparison for project-area streams. As indicated by the table, if the proposed project is implemented, using level 1 controls, significant long-term water quality benefits would be realized even if no further controls on nonpoint sources were applied. Most of the remaining problems would be caused by phenols, oil and grease, and coliforms (nonpoint).

In summation, these two comparative analyses demonstrate that, while additional control of nonpoint pollution will be necessary for meeting all water quality goals, the proposed project will benefit the project area on a long-term basis by furthering efforts to upgrade water quality in project streams to levels suitable for their classified uses - body contact recreation and public water supply.

TABLE 63

PREDICTED WATER QUALITY UNDER ALTERNATE CONTROL STRATEGIES - YEAR 2000

Stream	Existing Controls	Level 1	Level 2	Level 3
Meramec main stem	Poor	Fair-Good	Good	Good
Fishpot Creek	Poor	Fair	Fair	Fair-Good
Grand Glaize Creek	Poor	Poor-Fair	Fair	Fair-Good
Mattese Creek	Poor	Poor-Fair	Fair	Fair-Good
Keifer Creek	Poor	Poor-Fair	Fair-Good	Fair-Good

CHAPTER 9

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES LIKELY TO RESULT FROM IMPLEMENTATION OF THE PROPOSED PROJECT

An effect or trend is irreversible, and a resource used is irretrievable, if, once development has been carried out, the results cannot be reversed by any available countermeasure. An available countermeasure, for the purposes of this report, is an action which could reverse an effect and which is both technologically and economically feasible at this time. Thus, for example, the destruction of a given acreage of unique biological habitat involves both an irreversible change in land use and an irretrievable commitment of resources, since no action exists at this time which could be taken to recreate the complex ecological interrelationships of the original habitat. Conversely, the development of an interim treatment plant on a site previously subjected to terrain disturbance involves no such commitments. The land use effects of such development can be obviated by removal of the plant, materials can be sold or recycled, and capital outlay can be regained through sale of the land, customer billing or other means.

In this chapter, therefore, resource commitments discussed may be regarded as, for practical purposes, permanent.

The magnitude of the materials, energy, labor and land resources required for project construction are represented by estimated capital costs of $130 million. Sixty acres of land will be developed for the sewage treatment plant, regional pumping facility, and lagoons and approximately 60 miles of right-of-way will be required for the new subwatershed collector lines.

Purchasing the 60-acre tract will require a capital outlay of approximately $500,000 and will remove the acreage from local tax rolls. The tract is presently in agricultural use. Once the landform manipulation and development involved in the project are effected, it is extremely doubtful that the tract will ever be reconverted for agricultural purposes. This land use change is, therefore, regarded as irreversible.

A relatively small proportion of the development of the collector systems will involve irreversible or irretrievable commitments. Some construction will take place in existing railroad, highway, or sewer line right-of-way and will, hence, result in the continuation of an existing use and resource commitment. Much of the remaining collector system will pass through areas which do not have unique or particularly fragile resource systems. This will involve only temporary resource pre-emption which will be quickly reversed once the excavated areas are restored to their previous states. In some sectors, however, the potential for accidental irretrievable loss of certain resources does exist. These sectors, identified in Chapter 5 of this EIS, contain biological or archaeological resources which may be determined to be rare or unique. As emphasized elsewhere in this EIS, care must be taken in these areas to coordinate detailed planning with biological/archaeological studies and to use appropriate construction methods to avoid undue loss of these resources.

After the project has been constructed, resource commitment will derive from two principal sources: 1) operation and maintenance (O & M) of the facilities; and, 2) the indirect commitment of resources which will result from project implementation.

The initial operation of the regional facility (first 10 MGD module in operation) is estimated to require 14 employees and 8×10^6 kwrh annually at a total annual O & M cost of $620,000. At design conditions (all four modules operating for a total of 40 MGD), the facility will require an estimated 34 employees and 26×10^6 kwhr annually at a total annual O & M cost of $1,550,000.

Secondary urban development facilitated by the project will effect a series of irreversible trends requiring the irretrievable commitment of substantial land, raw materials and energy. Up to 6,000 acres of vacant and agricultural land will be converted to urban use. In the process, agricultural, scenic, vegetation, wildlife and archaeologic resources will be consumed or lost.

CHAPTER 10

PUBLIC PARTICIPATION

As discussed in Chapter 2 of this EIS, a three-phase public participation program was developed for the Lower Meramec project. This chapter discusses the efforts to elicit public opinion in each phase of the project and presents a summation of substantive comments received along with replies to those comments. Changes in the project or EIS which resulted from the comments are also discussed. Copies of questionnaires, public handouts, and letters sent to selected agencies are included in Appendix C.

Phase I of the program was carried out in two parts. The first involved conducting two public workshops to familiarize the public with the 201 Facilities Planning program for the Lower Meramec and the EIS process and its purposes, and to solicit public opinion on environmental concerns. The second part involved sending letters of inquiry to selected agencies in the project area to solicit their input. The two public workshops were held on May 24, 1976 in Ellisville and on June 24, 1976 in Arnold. The workshops featured a discussion of wastewater problems in the Lower Meramec, an explanation of the 201 and EIS processes, and group discussion of environmental concerns in the study area. Two handouts were presented to attendees. The first was a narrative summary of the problems and processes cited above. The second was a public opinion questionnaire. Copies of these handouts are included in Appendix B. Thirty-two individuals participated in the meeting, with 7 present at Ellisville and 25 in attendance at Arnold. The major concerns expressed at the meeting and replies to those concerns are as follows:

Question: What will be the fate of the small sewer companies if the trunk is constructed?

Response: Two main alternatives exist: they can either remain in business and contract with the regional trunk and plant operation for services or they might be acquired by the regional operator.

Question: Why isn't tertiary treatment being planned for a facility discharging into the Mississippi River? If the wastewaters are only given secondary treatment, aren't we just "shifting our problems

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downstream" to the Mississippi?

Response: Tertiary treatment is very expensive in terms of facilities, operating skills, and controls required and in the use of natural resources such as process chemicals and energy. Water quality modeling studies have shown that, largely due to the Mississippi's large flow rate (simply, its dilution capabilities), secondary and tertiary discharges would have virtually no detectable difference in impacts on the river's water quality. Therefore, only secondary treatment is recommended at this time.

Other substantive comments concerned the need for eliminating landfills on the floodplain (which were said to be leaching into the Meramec) and the need for future land-use planning and zoning in the study area to provide for "controlled growth". Neither of these problems is within the scope of this Facilities Plan.

Analysis of the questionnaire responses compiled from the workshop indicated that all attendees felt a wastewater treatment study of the Lower Meramec was needed. The major environmental concerns identified in most responses were related to: 1) projected population growth; 2) impacts on recreation uses; 3) impacts on quality of surface waters; 4) impacts on groundwater, and; 5) potential industrial development in the project area. All of these problems are addressed in Chapters 5 through 9 of this EIS.

The second part of this phase involved sending out letters of inquiry on June 9, 1976 to local agencies which might have a particular knowledge or familiarity with aspects of the 201 Plan for the study area. A copy of the letter is included in Appendix C. A list of agencies to which these letters were sent and a summation of responses received follows:

Valley Park Chamber of Commerce - No response

Meramec Valley Bassmasters, Inc. - No response

Missouri Scenic River Association - No response

Missouri Sportsmen fo a Clean Outdoors - No response

Meramec Basin Association - No response

St. Louis Open Space Council - Expressed concern for preservation of open space in study area through planning and zoning.

St. Louis Jaycees - No response

Home Builders Association of Greater St. Louis - Projected, on the basis of attitude studies, that South St. Louis County will be one of the most preferred and fastest-growing living locations in the metropolitan area. Urged that project planning take this growth potential into account.

St. Louis Rotary Club - No response

Sierra Club, Ozark Chapter - No response

St. Louis Audubon Society - No response

Anglers of Missouri - No response

Phase II of the public participation program centered on a public workshop held in Fenton on October 13, 1977. Two weeks prior to this meeting, preliminary draft copies of the Facilities Plan and Chapters 2 and 3 of this EIS were put on display at local libraries and at MSD's and RETA's offices for public review. Forty individuals attended the workshop. The major topics of discussion were alternative means of solving the Lower Meramec's wastewater problems and the potential environmental impacts of the alternatives. Questionnaires were again distributed. Analysis of the compiled responses indicates those responding had the following opinions:

1) A regional system was favored in all responses except one. That one response favored a subregional system with higher level (tertiary) treatment. The reason stated for this choice was that the person responding felt that no new facilities, which would treat wastes only to a secondary level, should be implemented. The reasons given by those favoring the regional alternative (in order of number of responses) were lowest costs, most pollutants removed from the Meramec, least energy and land resources

required, and greatest reliability.

2) All persons responding favored "growth with good planning" for the study area. Concern was expressed that inadequate planning and zoning would lead to the spread of urban blight, uncontrolled development, and/or loss of recreational resources in the area.

3) Most of those responding indicated that they now use the Meramec for some form of recreation. Swimming and canoeing were most often mentioned. All responses except one indicated that those responding would use the Meramec for recreation more often if there were better access and cleaner water.

4) All persons responding indicated they felt that the expenditure of time and money needed to remove discharges from the Meramec is justifiable.

Phase III of the program will consist of public review of the draft EIS, including a public hearing. Comments received during that review and responses to those comments will be included in the final EIS.

CHAPTER 11

SIGNIFICANT ISSUES TO BE RESOLVED

The systems of collection, conveyance, and treatment which will result in technically optional wastewater management for the project area with a minimum of environmental degradation have been selected prior to this stage of the 201 process. However, both the extent to which the recommended plan will be successful in providing efficient service and the direction of the developmental changes which would be facilitated by plan implementation are dependent on a number of issues which have not yet been resolved. These issues are of two principal types: 1) those issues which are directly related to subsequent decisions regarding implementation of the plan; and 2) those issues which, while not within the scope of the 201 process, will significantly affect both the success of the plan in ameliorating water quality problems and the future "quality of life" in the study area.

Decisions which must be made in construction drawings and specifications for the project are included in the first type of issue. The degree to which these documents reflect an attempt to avoid sensitive areas and include mitigative measures will have a major effect on construction impacts. Also included in this type are institutional, management, and jurisdictional issues which will affect project success. Chief among these are:

1) MSD's acquisition of sewer systems in parts of St. Louis County occured quite recently (1977). MSD had no previous access to these systems and, therefore, could not perform infiltration/inflow and structural evaluation studies. The condition of these systems will have to be determined prior to the development of construction plans for these areas.

2) The lack of MSD jurisdiction in Jefferson County makes service to that portion of the study area dependent on contractual agreements between MSD and designated Jefferson County authorities. At present, the only corporate entity in the Jefferson County portion is the City of Arnold. No other "designated authorities" exist. Additional unresolved issues related to this lack of jurisdiction include the manner in which the wastewaters of the study area portion of Jefferson

County will be collected and conveyed to the regional plant, the manner in which costs will be shared, and the timing of service agreements, in terms of phased development of the regional plant.

The second group of issues, those not within the scope of 201 planning, are all dependent on future regional planning. Included in this group are:

1) Plans for control of non-point pollution. As discussed in Chapter 8, while the 201 Plan offers a solution to point-source wastewater problems, violations of proposed standards will still occur periodically, if additional efforts for non-point control are not carried out. Water quality problems could still be serious without non-point controls in terms of the use classifications of project area streams (i.e. body contact recreation and public water supply) and the characteristic components of urban runoff (phenols, hydrocarbon, heavy metals and streptococci). The promulgation of recommendations for non-point control is within the province of the 208 planning process.

2) Future regional planning and zoning, which will affect development in the area, and secondary impacts related to that development.

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GLOSSARY

Air quality maintenance area - Area in which air quality (as shown by modeling) is, or is projected to be, in violation of federal standards for one or more of the following pollutants: sulfur dioxide, particulate matter; carbon monoxide, nitrogen dioxide, photochemical oxidants.

Algal blooms - Sporadic drastic increase in algae in a water body, usually accompanied by lowering of dissolved oxygen and inhibition of photosynthetic activity of planktons.

Alluvial soils - Soils deposited by streams.

Ambient - Pertaining to existing conditions in an area; in air quality, that portion of the atmosphere outside of buildings which is accessible to the public during a specified time period.

Anadromous - Ascending rivers to spawn, includes salmon, shad, striped bass, and some trout.

Anticline - A geologic fold that is convex upward at the axis or had such an attitude at some stage of development.

Aquiclude - A formation which will not transmit water fast enough for an appreciable supply for a well or spring.

Aquifer - Stratium or zone below the surface of the earth capable of yielding water, as from a well.

Benthic - Pertaining to organisms living at the bottom of a body of water.

BOD - Biochemical oxygen demand: a measure of the oxygen-consuming property of a body of water through biological oxidation.

Carrying capacity - Ability of an environment to support life; ability of an environment to withstand stress.

Catastomid - Member of the fish family *Catastomidae*, which includes bass, crappie, sunfish, and rock bass.

Clastic (rocks) - Consisting of fragments that have been individually moved from their place of origin.

COD - Chemical oxygen demand; a measurement of the oxygen-consuming property of a body of water through chemical oxidation.

Colluvial soils - Soils deposited by gravity from higher elevations; usually at the foot of a slope or cliff.

dBA - A decibel unit on a scale weighted to approximate the sensitivity of the human ear to different frequencies of sound.

Decible - Unit of sound level measurement (abbreviated dB); the logarithm of the difference between the sound pressure level of interest and the reference level of .0002 dynes/cm^2. The reference level is approximately the faintest sound detectable by the ear of a healthy young adult in an extremely quiet environment.

Diel - Referring to a 24-hour day; usually includes adjacent night.

DO - Dissolved oxygen.

Dolomite - Sedimentary rock approaching calcium magnesium carbonate $[Ca\mu g(CO_3)_2]$ in composition.

Edge - In ecological descriptions, the area where two different adjacent habitats intergrade into one another, displaying characteristics of both habitats.

Effluent - Flowing out or forth; an outflow

Epicontinental (seas) - Portions of the sea which extend (or at one time extended) into the interior of a continent.

Eutrophic - Condition of a body of water in which nutritive matter content is high and dissolved oxygen is low.

Fecal coliform - Rod-shaped bacteria generally found in intestinal tracts of mammals and living for only short periods outside that environment; used as indicators of recent fecal contamination.

Fecal streptocci - Ball-shaped bacteria in chain-like groups, generally found in mammal intestines though not restricted to that environment; used as indicators of fecal contamination.

Hydrograph - A graph showing stage, flow, velocity, or other property of water in relation to time.

Hydrologic - Pertaining to water.

Indigenous - Native; not imported or introduced.

Infiltration (into sewers) - Entry of groundwater into a system.

Inflow (into sewers) - Entry of excess water other than groundwater into a sewer system; usually associated with uncovered manholes and unauthorized hookups to storm drainage systems.

Influent stream - Tributary; with respect to groundwater, contributing water to a groundwater aquifer.

Interspecific competition - Competition between different species of organisms for food, cover, or other habitat requirements.

Karst topography - Irregular topography, developed by the solution of surface and groundwaters, in which the bedrock is honeycombed by tunnels and "sink holes". Usually underlain by caverns and underground streams.

Lentic waters - Standing inland waters, as lakes, ponds, and swamps.

Lift station - Device to transfer flow over high points in topography; usually synonymous with "pump stations."

Losing stream - A stream in which all or part of the flow is "lost" to the groundwater system.

Lotic waters - Running waters, as streams, rivers.

Mesophytic - Of, pertaining to, or adapted to intermediate moisture conditions typical of watered land of the temperate zone.

Non-point pollution - Pollution attributable to general runoff in a watershed or general areawide atmospheric conditions and not traceable to discrete sources such as smokestacks or outlet pipes.

Oligotrophic - Condition of a body of water in which nutritive matter content is low and dissolved oxygen is high.

One-hundred-year flood - A flood level predicted to occur at a frequency of once every hundred years for a given body of water.

Percid - Member of the fish family Percidae, which includes freshwater perches and darters.

Pyytoplankton - The plant organisms of plankton.

Plankton - Aquatic organisms which float freely or display limited mobility.

Point-source pollution - Pollution traceable to discrete sources such as outlet pipes, smokestacks, etc.

Proglacial - Applied to deposits made beyond the limits of the glacier itself.

Protected stream - Missouri Clean Water Commission - classified waterway into which, due to the need to preserve open-space quality near urban areas, no discharges are allowed other than uncontaminated cooling water.

Roll back modeling - A method of predicting long-term air quality trends which assumes that the magnitudes of air pollutant levels in a given area are directly proportional to the magnitudes of air pollutant emissions within that area.

Salmonid - Member of the fish family Salmonidae, which includes salmon and trout.

Slaking - Crumbling and disintegration of earth materials when exposed to air or moisture.

Syncline - A fold in rocks in which the strata dips inward from both sides toward the axis.

Trophic - Pertaining to growth or nutrition.

Trophic level - A stage in the food chain of an ecosystem in which all organisms obtain their food in the same number of steps or in the same general manner.

Xerophytic - Of, pertaining to, or adapted to dry conditions.

Zooplankton - The animal organisms of plankton.

APPENDIX A

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TABLE A1

AIR QUALITY STANDARDS(a)(b)
(FEDERAL)

	SO_2	Particulate Matter	CO	Oxidant	NO_x	HC
Primary Standards						
Annual						
Arithmetic mean	0.03				0.05	
Geometric mean		75(c)				
24-hour max	0.14	260				
8-hour max			9			
3-hour max						160(c)
1-hour max			35	0.8		
Secondary Standards (where different from primary)						
Annual						
Arithmetic mean	0.023					
Geometric mean		60(c)				
24-hour max	0.10	150(c)				
3-hour max	0.50					

NOTES: (a)As published by USEPA, April 30, 1971
(b)In ppm except where specified
(c)Micrograms per cubic meter

Source: (033)

TABLE A1

AIR QUALITY STANDARDS [(a)]
(AMBIENT)

Pollutant	Concentration	Remarks
1. Sulfur oxides		
Sulfation	0.25 mg SO_3/100 cm^2/day	Maximum annual average
	0.50 mg SO_3/100 cm^2/day	Maximum month value
Sulfur dioxide[(b)]	0.02 ppm	Maximum annual average (24-hour sampling time)
	0.10 ppm	24-hour average not be be exceeded over 1 day in any 3-month period
Suspended sulfate (analysis of high-volume filters)	4 μg/m^3	Allowable maximum annual average
	12 μg/m^3	Not to be exceeded over 1 percent of the time
Sulfuric acid mist	4 μg/m^3	Allowable maximum annual average
	12 μg/m^3	Not to be exceeded over 1 percent of the time
	30 μg/m^3	Hourly average not to be exceeded over 1 percent of the time
2. Hydrogen Sulfide	0.05 ppm	1/2 hour average not to be exceeded over 2 times per year
	0.03 ppm	1/2 hour average not to be exceeded over 2 times in any 5 consecutive days
3. Oxidant (total)[(c)]	0.15 ppm	Maximum allowable 1-hour value
4. Dustfall[(d)(e)]	10 tons/sq. mi./mo.	3-month average above background in all areas except those zoned heavy industrial

TABLE A1

AIR QUALITY STANDARDS (a)
(AMBIENT)
(continued)

Pollutant	Concentration	Remarks
	25 tons/sq. mi./mo.	3-month average above background in zoned heavy industrial areas
5. Suspended particulates (high-volume sampler)	75 $\mu g/m^3$	Annual geometric mean
	200 $\mu g/m^3$	Annual 99th percentile
6. Soiling index	0.4 Coh/1,000 lineal ft.	Annual geometric mean

NOTES: (a) All standards, unless otherwise indicated, refer to places where people live or an undesirable effect could result from levels above the standard.

(b) By West-Gacke or conductometric methods

(c) Potassium iodide colorimetric method of measurement

(d) Use background value of 5.0 tons/sq. mi./mo. in all areas

(e) Total dustfall including water soluble and water insoluble and all other components

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN

LYCOPODIALES
  Lycopodiaceae - Clubmoss Family

Lycopodium lucidulum Michx. var. lucidulum

SELAGINELLALES
  Selaginellaceae - Spikemoss Family

Selaginella apoda (L.) Fernald
Selaginella rupestris (L.) Spring

ISOETALES
  Isoetaceae - Quillwort Family

Isoetes melanopoda Gay & Durieu f. melanopoda
Isoetes butleri Engelm

EQUISETALES
  Equisetaceae - Horsetail Family

Equisetum arvense L.
Equisetum kansanum Schaffn.
Equisetum laevigatum A. Br.
Equisetum hyemale var. elatum (Engelm.) Morton

OPHIOGLOSSALES
  Ophioglossaceae - Adder's-Tongue Family

Botrychium dissectum Spreng. var. dissectum
Botrychium dissectum var. obliquum (Muhl.) Clute
Botrychium virginianum (L.) Sw. var. virginianum
Ophioglossum engelmanni Prantl.

FILICALES
  Osmundaceae - Royal Fern Family

Osmunda regalis L. var. spectabilis (Willd.) Gray f. spectabilis
Osmunda cinnamomea L.
Osmunda claytoniana L.
  Polypodiaceae - Fern Family, Polypody Family

Pteridium aquilinum (L.) Kuhn var. latiusculum (Desv.) Underw.
Pteridium aquilinum var. pseudocaudatum (Clute) Heller
Adiantum capillus-veneris L.
Adiantum pedatum L. var. pedatum
Pellaea glabella Mett. ex Kuhn var. glabella
Pellaea atropurpurea f. atropurpurea (L.) Link
Pellaea atropurpurea f. cristata (Trel.) Clute
Notholaena dealbata (Pursh) Kunze
Cheilanthes lanosa (Michx.) D. C. Eaton
Cheilanthes feei Moore
Polypodium polypodioides (L.) Watt var. Michauxianum Weath.
Polypodium vulgare L. var. virginianum (L.) Eaton
Onoclea sensibilis L. f. sensibilis
Asplenium ruta-muraria L. var. cryptolepis (Fern.) Wherry
Asplenium trichomanes L.
Asplenium resiliens Kunze
Asplenium platyneuron var. platyneuron f. platyneuron (L.) Oakes
Asplenium platyneuron var. platyneuron f. serratum (E. S. Miller) Hoffm.
Asplenium x ebenoides R. R. Scott
Camptosorus rhizophyllus (L.) Link
Athyrium pycnocarpon (Spreng.) Tidestr.
Athyrium thelypteroides (Michx.) Desv.
Athyrium filix-femina var. asplenioides (Michx.) Farw.
Athyrium filix-femina var. michauxii f. rubellum (Gilbert) Farwell
Woodsia obtusa (Spreng.) Torr.
Cystopteris fragilis var. protrusa Weath.
Cystopteris bulbifera f. bulbifera (L.) Bernh.
Thelypteris hexagonoptera (Michx.) Weath.
Thelypteris palustris Schott, var. pubescens (Lawson) Fern.
Dryopteris austriaca var. spinulosa (Muhl.) Fiori
Dryopteris austriaca var. intermedia (Muhl.) Morton

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Dryopteris marginalis (L.) Gray
Polystichum acrostichoides f. *acrostichoides* (Michx.) Schott

CONIFERAE
  Pinaceae - Pine Family

Pinus nigra Arnold var. *nigra*
Pinus echinata Mill.
Pinus virginiana Mill.

  Cupressaceae - Cypress Family

Juniperus virginiana var. *virginiana* L.
Juniperus virginiana var. *creba* Fern. & Grisc.

PANDANALES
  Typhaceae - Cat-tail Family

Typha latifolia f. *latifolia* L.

  Sparganiaceae - Bur-reed Family

Sparganium eurycarpum Engelm.
Sparganium androcladum (Engelm.) Morong
Sparganium americanum Nutt.

NAJADALES
  Najadaceae - Pondweed Family

Potamogeton pectinatus L.
Potamogeton foliosus Raf.
Potomogeton diversifolius Raf.
Potamogeton pulcher Tuckerm.
Potamogeton nodosus Poir.
Zannichellia palustris var. *major* (Boenn.) W. D. J. Koch
Najas guadalupensis (Spreng.) Magnus

ALISMALES
  Alismaceae - Water Plantain Family

Alisma plantago-aquatica var. *americanum* J. A. Schultes & Schult
Echinodorus cordifolius (L.) Griseb.
Echinodorus berteroi (Spreng.) Fassett var. *lanceolatus* (Engelm.) Fassett
Echinodorus tenellus (Mart.) Buch. var. *parvulus* (Engelm.) Fassett
Sagittaria montevidensis Cham. & Schl., subsp. *calycina* (Engelm.) Bogin
Sagittaria rigida Pursh f. *rigida*
Sagittaria rigida f. *elliptica* (Engelm.) Fern.
Sagittaria graminea Michx. var. *graminea* Michx.
Sagittaria engelmanniana subsp. *brevirostra* (Mack. & Bush) Bogin
Sagittaria latifolia var. *obtusa* (Muhl.) Wieg.

HYDROCHARITALES
  Hydrocharitaceae - Frogbit Family

Anacharis nuttallii Planch.
Vallisneria americana Michx.

GRAMINALES
  Gramineae - Grass Family

Bromus catharticus Vahl
Bromus inermis Leyss
Bromus purgans L.
Bromus latiglumis (Shear) Hitchc.
Bromus secalinus L.
Bromus mollis L.
Bromus racemosus L.
Bromus squarrosus L.
Bromus japonicus Thunb.

TABLE A2
FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Bromus rigidus Roth.
Bromus tectorum L. var. *tectorum*
Festuca octoflora var. *octoflora* Walt.
Festuca octoflora var. *tenella* (Willd.) Fern.
Festuca Octoflora var. *glauca* (Nutt.) Fern.
Festuca myuros L.
Festuca elatior var. *elatior* f. *elatior* L.
Festuca elatior var. *arundinacea* (Schreb.) Wimmer
Festuca paradoxa Desv.
Festuca rubra var. *rubra* L.
Festuca rubra var. *commutata* Gaudin
Festuca rubra var. *arenaria* (Osbeck)
Festuca ovina var. *ovina* L.
Festuca ovina var. *duriuscula* (L.) Koch
Puccinellia distans (L.) Parl.
Puccinellia airoides (Nutt.) Wats. & Coult.
Glyceria septentrionalig var. *septentrionalis* Hitchc.
Glyceria striata var. *striata* (Lam.) Hitchc.
Poa chapmaciana Scribn.
Poa annua L.
Poa compressa L.
Poa pratensis L.
Poa sylvestris A. Gray
Poa Wolfii Scribn.
Eragrostis hypnoides (Lam.) BSP.
Eragrostis capillaris (L.) Nees
Eragrostis frankii C. A. Meyer var. *frankii*
Eragrostis pilosa (L.) Beauv.
Eragrostis pectinacea (Michx.) Nees
Eragrostis cilianensis (All.) Hitchcock
Eragrostis poaeoides Beauv.
Eragrostis trichodes (Nutt.) Wood
Eragrostis spectabilis var. *spectabilis* (Pursh) Steud.
Diplachne fascicularis (Lam.) Beauv.
Diarrhena americana Beauv.
Distichlis stricta (Torr.) Rvdb.
Uniola latifolia Michx.
Dactylis glomerata L.
Melica nitens Nutt.
Tridens flavus (L.) Hitchc.
Agropyron repens var. *subulatum* (Schreb.) Reichenb. f. *subulatum*
Agropyron repens var. *subulatum* f. *vaillantianum* (Wulf. & Schreb.) Fern.
Agropyron smithii Rydb.
Agropyron trachycaulum (Link) Steud. var. *trachycaulum*
Triticum aestivum L.
Aegilops cylindrica Host
Secale cereale L.
Elymus villosus f. *villosus* Muhl.
Elymus canadensis L.
Elymus virginicus var. *virginicus* f. *virginicus* L.
Elymus virginicus var. *jejunus* (Ramaley) Bush
Elymus virginicus var. *submuticus* Hook.
Hystrix patula Moench f. *patula*
Hordeum jabatum L. var. *jubatum*
Hordeum pusillum Nutt.
Hordeum vulgare L. var. *vulgare*
Lolium perenne L.
Lolium multiflorum var. *multiflorum* Lam.
Lolium temulentum var. *temulentum* (L.) Darnel
Lolium temulentum var. *macrochaeton* A. Br.
Roeleria cristata (L.) Pers.
Sphenopholis obtusata var. *obtusata* (Michx.) Scribn.
Sphenopholis obtusata var. *lobata* (Trin.) Scribn.
Sphenopholis intermedia Rydb.
Aira elegans Willd.
Avena fatua L.
Avena sativa L.
Danthonia spicata var. *spicata* (L.) Beauv.
Calamagrostis canadensis var. *canadensis* (Michx.) Beauv.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Calamovilfa longifolia (Hook.) Scribn. var. *longifolia*
Agrostis alba L.
Agrostis tenuis Sibth.
Agrostis elliottiana Schultes
Agrostis hyemalis (Walt.) BSP. var. *hyemalis*
Agrostis perennans var. *perennans* (Walt.) Tuckerm.
Cinna arundinacea var. *arundinacea* L.
Alopecurus carolinianus Walt.
Phleum pratense L. var. *pratense* f. *pratense*
Muhlenbergia racemosa (Michx.) BSP.
Muhlenbergia sobolifera f. *sobolifera* (Muhl.) Trin.
Muhlenbergia tenuiflora (Willd.) BSP.
Muhlenbergia frondosa f. *frondosa* (Poir.) Fern.
Muhlenbergia glabriflora Scribn.
Muhlenbergia sylvatica var. *sylvatica* f. *sylvatica* Torr.
Muhlenbergia sylvatica var. *sylvatica* f. *attenuata* (Scribn.) Palmer & Steyermark
Mulhenbergia mexicana f. *mexicana* (L.) Trin.
Muhlenbergia schreberi var. *schreberi* Gmel.
Sporobolus vaginiflorus var. *vaginiflorus* (Torr.) Wood
Sporobolus vaginiflorus var. *inaequalis* Fern.
Sporobolus neglectus var. *neglectus* Nash
Sporobolus asper var. *asper* (Michx.) Kunth
Sporobolus asper var. *pilosus* (Vasey) Hitchc.
Sporobolus asper var. *Hookeri* (Trin.) Vasey
Sporobolus clandestinus var. *clandestinus* (Biehler) Hitchc.
Sporobolus clandestinus var. *canovirens* (Nash) Steyermark & Kucera
Sporobolus heterolepis Gray
Sporobolus cryptandrus (Torr.) A. Gray var. *cryptandrus*
Heleochloa schoenoides (L.) Host
Brachyelytrum erectum (Schreb.) Beauv. var. *erectum*
Aristida basiramea Engelm.
Aristida dichotoma var. *dichotoma* Michx.
Aristida dichotoma var. *curtissii* Gray
Aristida oligantha Michx.
Aristida intermedia Scribn. & Ball
Aristida longespica var. *longespica* Poir.
Aristida purpurascens Poir.
Leptochloa filiformis var. *filiformis* (Lam.) Beauv.
Leptochloa filiformis var. *attenuata* (Nutt.) Steyermark & Kucera
Eleusine indica (L.) Gaertn.
Cynodon dactylon (L.) Pers.
Spartina pectinata Link
Gymnopogon ambiguus (Michx.) BSP.
Chloris verticillata Nutt.
Bouteloua curtipendula (Michx.) Torr.
Bouteloua gracilis (HBK) Lag.
Anthoxanthum odoratum L.
Phalaris canariensis L.
Leersia lenticularis Michx.
Leersia oryzoides f. *oryzoides* (L.) Sw.
Leersia virginica Willd.
Digitaria sanguinalis var. *sanguinalis* (L.) Scop.
Digitaria ischaemum var. *ischaemum* (Schreb.) Muhl.
Digitaria filiformis var. *filiformis* (L.) Koel.
Leptoloma cognatum (Schultes) Chase
Paspalum fluitans (Ell.) Kunth
Paspalum pubiflorum Rupr. var. *glabrum* Vasey
Paspalum ciliatifolium var. *muhlenbergii* (Nash) Fern.
Paspalum ciliatifolium var. *stramineum* (Nash) Fern.
Paspalum bushii Nash
Paspalum dilatatum Poir.
Paspalum laeve var. *circulare* (Nash) Fern.
Panicum depauperatum Muhl. var. *depauperatum*
Panicum perlongum Nash
Panicum linearifolium Scribn. var. *linearifolium*
Panicum laxiflorum Lam.
Panicum microcarpon Muhl.
Panicum dichotomum L. var. *dichotomum*
Panicum dichotomum var. *barbulatum* (Michx.) Wood

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Panicum lanuginosum var. *lindheimeri* (Nash) Fern.
Panicum lanuginosum var. *implicatum* (Scribn.) Fern.
Panicum lanuginosum var. *fasciculatum* (Torr.) Fern.
Panicum praecocius Hitchc. & Chase
Panicum villosissimum Nash var. *villosissimum*
Panicum sphaerocarpon var. *sphaerocarpon* Ell.
Panicum polyanthes Schult.
Panicum oligosanthes var. *helleri* (Nash) Fern.
Panicum oligosanthes var. *scribnerianum* (Nash) Fern.
Panicum leibergii (Vasey) Scribn.
Panicum clandestinum L.
Panicum latifolium L.
Panicum boscii var. *boscii* Poir.
Panicum geminatum Forsk.
Panicum texanum Buckl.
Panicum dichotomiflorum Michx.
Panicum flexile (Gattinger) Scribn.
Panicum gattingeri Nash
Panicum philadelphicum Bernh. var. *philadelphicum*
Panicum capillare L. var. *capillare*
Panicum capillare var. *occidentale* Rydb.
Panicum miliaceum L.
Panicum virgatum L. var. *virgatum*
Panicum agrostoides Spreng.
Panicum anceps Michx. var. *anceps*
Echinochloa colonum (L.) Link f. *colonum*
Echinochloa crusgalli (L.) Beauv. var. *crusgalli* f. *crusgalli*
Echinochloa crusgalli var. *crusgalli* f. *longiseta* (Trin.) Farw.
Echinochloa muricata (Beauv.) Fern. var. *muricata*
Echinochloa muricata var. *ludoviciana* Wieg.
Echinochloa muricata var. *occidentalis* Wieg.
Setaria glauca (L.) Beauv.
Setaria geniculata (Lam.) Beauv.
Setaria verticillata (L.) Beauv. var. *verticillata*
Setaria verticillata var. *ambigua* (Guss.) Parl.
Setaria viridis (L.) Beauv. var. *viridis*
Setaria faberii Herrm.
Setaria italica (L.) Beauv.
Cenchrus longispinus (Hack.) Fern.
Miscanthus floridulus (Lab.) Warb. Eulalia
Erianthus ravennae (L.) Beauv.
Arthraxon hispidus (Thunb.) Makino var. *hispidus*
Cynosurus echinatus L.
Paspalum urvillei Steud.
Pernisetum ciliare (L.) Link
Andropogon scoparius Michx.
Andropogon gerardi var. *gerardi* Vitman [G]
Andropogon virginicus L.
Andropogon elliottii Chapm. var. *elliottii*
Andropogon saccharoides Sw.
Sorghum halepense (L.) Pers.
Sorghum dochna var. *technicum* (Koern.) Snowden
Sorghum sudanense Stapf
Sorghastrum nutans (L.) Nash
Tripsacum dactyloides L.
Zea mays L.

Cyperaceae - Sedge Family

Cyperus flavescens L., var. *poaetormis* (Pursh) Fern.
Cyperus diandrus Torr.
Cyperus rivularis Kunth var. *rivularis* f. *rivularis*
Cyperus aristatus Rottb.
Cyperus compressus L.
Cyperus acuminatus Torr. & Hook.
Cyperus erythrorhizos Muhl.
Cyperus ferruginescens Boeckl.
Cyperus esculentus var. *esculentus* f. *esculentus* L.
Cyperus strigosus var. *strigosus* L.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Cyperus refractus Engelm.
Cyperus lancastriensis Porter
Cyperus schweinitzii Torr.
Cyperus filiculmis var. *filiculmis* Vahl.
Cyperus filiculmis var. *macilentus* Fern.
Cyperus ovularis var. *ovularis* (Michx.) Torr.
Cyperus ovularis var. *sphaericus* Boeckl.
Cyperus tenuifolius (Steud.) Dandy
Dulichium arundinaceum (L.) Britt.
Eleocharis quadrangulata (Michx.) R. & S. var. *crassior* Fern.
Eleocharis acicularis var. *acicularis* f. *acicularis* (L.) R. & S.
Eleocharis engelmanni Steud.
Eleocharis obtusa (Willd.) Schultes var. *obtusa*
Eleocharis smallii Britt.
Eleocharis macrostachya Britt.
Eleocharis calva Torr.
Eleocharis compressa Sulliv.
Eleocharis tenuis (Willd.) Schultes var. *verrucosa* Svenson
Bulbostylis capillaris (L.) C. B. Clarke
Fimbristylis caroliniana (Lam.) Fern.
Fimbristylis autumnalis (L.) R. & S.
Scirpus americanus Pers.
Scirpus olneyi Gray
Scirpus validus Vahl var. *creber* Fern.
Scirpus fluviatilis (Torr.) Gray
Scirpus atrovirens var. *atrovirens* f. *atrovirens* Willd.
Scirpus lineatus Michx.
Hemicarpha drummondii Nees
Hemicarpha micrantha (Vahl) Pax
Rhynchospora corniculata (Lam.) Gray var. *corniculata*
Rhynchospora capillacea Torr.
Scleria triglomerata Michx.
Scleria pauciflora var. *pauciflora* Muhl.
Scleria verticillata Muhl.
Carex douglasii Boott
Carex retroflexa var. *retroflexa* Muhl.
Carex convoluta Mackenz.
Carex rosea Schkuhr
Carex cephalophora var. *cephalophora* Muhl.
Carex cephalophora var. *mesochorea* (Mackenz.) Gl.
Carex leavenworthii Dew.
Carex muhlenbergii var. *muhlenbergii* Schk.
Carex muhlenbergii var. *enervis* Boott
Carex gravida var. *gravida* f. *gravida* Bailey
Carex gravida var. *lunelliana* (Mackenz.) Herm.
Carex aggregata Mackenz.
Carex sparganiodes Muhl.
Carex vulpinoidea Michx.
Carex annectens var. *annectens* Bickn.
Carex stipata var. *stipata* Muhl.
Carex crus-corvi Shuttlw.
Carex conjuncta Boott
Carex muskingumensis Schwein
Carex scoparia var. *scoparia* Schkuhr
Carex tribuloides Wahlenb.
Carex projecta Mackenz.
Carex tenera Dewey
Carex festucacea Schkuhr
Carex brevior (Dew.) Mackenz.
Carex molesta Mackenz.
Carex bicknellii Britt
Carex jamesii Schwein
Carex artitecta Mackenz.
Carex umbellata f. *umbellata* Schkuhr
Carex umbellata f. *vicina* (Dew.) Wieg.
Carex eburnea Boott
Carex hirtifolia Mackenz.
Carex meadii Dew.
Carex careyana Torr.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Carex digitalis var. *digitalis* Willd.
Carex albursina Sheldon
Carex blanda Dew.
Carex gracilescens Steud.
Carex granularis var. *granularis* Muhl.
Carex granularis var. *haleana* (Olney) Porter
Carex crawei Dewey
Carex oligocarpa Schkuhr
Carex hitchcockiana Dew.
Carex amphibola var. *amphibola* Steud.
Carex amphibola var. *rigida* (Bailey) Fern.
Carex amphibola var. *turgida* Fern.
Carex flaccosperma var. *glaucodea* (Tuckerm.) Kukenth.
Carex gracillima Schwein
Carex davisii f. *davisii* Schw. & Torr.
Carex davisii f. *glabrescens* Kukenth.
Carex complanata var. *hirsuta* (Bailey) Gl.
Carex caroliniana Schw.
Carex bushii Mackenz.
Carex lanuginosa Michx.
Carex shortiana Dewey
Carex x *deamii* F. J. Herm.
Carex nebraskensis Dewey
Carex haydenii Dew.
Carex emoryi Dew.
Carex crinita var. *crinita* Lam.
Carex crinita var. *brevicrinis* Fern.
Carex hystricina Muhl.
Carex lurida Wahlenb.
Carex schweinitzii Dew.
Carex hyalinolepis Steud.
Carex frankii Kunth
Carex squarrosa L.
Carex typhina Michx.
Carex vesicaria L. var. *monile* (Tuckerm.) Fern.
Carex grayii var. *grayii* Carey
Carex grayii var. *hispidula* Gray
Carex louisianica Bailey
Carex lupulina var. *lupulina* Muhl.
Carex lupulina var. *pedunculata* Gray
Carex lupuliformis Sartwell

ARALES
Araceae - Arum Family

Arisaema atrorubens f. *atrorubens* (Ait.) Blume
Arisaema dracontium (L.) Schott
Peltandra virginica f. *virginica* (L.) Schott & Endl.
Acorus calamus L.

Lemnaceae - Duckweed Family

Spirodela polyrhiza (L.) Schleid.
Lemna minor L.
Lemna perpusilla Torr.
Wolffia columbiana Karst.

Commelinaceae - Spiderwort Family

Tradescantia subaspera Ker. var. *subaspera*
Tradescantia virginiana L. f. *virginiana*
Tradescantia ohiensis Raf.
Tradescantia bracteata Small
Commelina communis L.
Commelina diffusa Burm
Commelina virginica L.
Commelina erecta var. *angustifolia* (Michx.) Fern. f. *angustifolia*

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Pontederiaceae - Pickerel-weed Family

Pontederia cordata f. *latifolia* (Farw.)
Heteranthera reniformis R. & P.
Heteranthera limosa (Sw.) Willd.
Heteranthera dubia (Jacq.) MacM.

LILIALES
Juncaceae - Rush Family

Juncus effusus var. *solutus* Fern. & Wieg.
Juncus secundus Beauv.
Juncus tenuis f. *tenuis* Willd.
Juncus interior Wieg.
Juncus marginatus var. *marginatus* Rostk.
Juncus biflorus f. *biflorus* Ell.
Juncus biflorus f. *adinus* Fern. & Grisc.
Juncus scirpoides Lam. var. *scirpoides*
Juncus brachycarpus Engelm
Juncus torreyi Coville
Juncus acuminatus Michx.
Juncus nodatus Coville
Luzula bulbosa (Wood) Rydb.

Liliaceae - Lily Family

Stenanthium gramineum (Ker) Morong var. *gramineum*
Veratrum woodii Robbins
Melanthium virginicum L.
Uvularia grandiflora Sm.
Allium tricoccum Ait.
Allium sativum L.
Allium vineale L. f. *vineale*
Allium canadense L.
Allium mutabile Michx.
Allium cernuum Roth
Allium stellatum Fraser
Nothoscordum bivalve (L.) Britton
Hemerocallis fulva L. var. *fulva*
Lilium michiganense Farw.
Erythronium americanum Ker
Erythronium albidum Nutt. var. *albidum*
Erythronium albidum var. *mesochoreum* (Knerr) Rickett
Camassia scilloides (Raf.) Cory f. *scilloides*
Camassia scilloides f. *petersenii* Steyerm.
Ornithogalum umbellatum L.
Muscari botryoides (L.) Mill.
Yucca smalliana Fern.
Asparagus officinalis L.
Smilacina racemosa (L.) Desf. var. *racemosa*
Polygonatum biflorum (Walt.) Ell. f. *biflorum*
Polygonatum canaliculatum (Muhl.) Pursh
Trillium sessile L. f. *sessile*
Trillium sessile f. *viridiflorum* Beyer
Trillium viride Beck var. *viride*
Trillium recurvatum Beck f. *recurvatum*
Trillium recurvatum f. *shayi*
Trillium flexipes Raf. f. *flexipes*
Smilax herbacea var. *lasioneura* (Hook.) A. DC.
Smilax ecirrhata (Engelm.) Wats.
Smilax tamnoides L. var. *hispida* (Muhl.) Fern.
Smilax bona-nox L. var. *hederaefolia* (Beyrich) Fern.

Dioscoreaceae - Yam Family

Dioscorea quaternata (Walt.) J. F. Gmel.
Dioscorea villosa L. f. *villosa*

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Amaryllidaceae - Amaryllis Family

Hypoxis hirsuta (L.) Coville
Agave virginica L. f. *virginica*

Iridaceae - Iris Family

Iris virginica L. var. *shrevei* (Small)
Iris brevicaulis Raf.
Belamcanda chinensis (L.) DC.
Sisyrinchium albidum Raf.
Sisyrinchium campestre f. *campestre* Bickn.
Sisyrinchium bermudiana L. em. Fernald

ORCHIDALES
Orchidaceae - Orchid Family

Cypripedium calceolus var. *pubescens* (Willd.) Correll
Cypripedium candidum Muhl.
Orchis spectabilis L.
Habenaria flava var. *herbiola* (R. Br.) Ames & Correll
Habenaria lacera (Michx.) Lodd. var. *lacera*
Habenaria leucophaea (Nutt.) Gray
Triphora trianthophora (Sw.) Rydb.
*Spiranthes tuberosa*var. *tuberosa* Raf.
Spiranthes gracilis (Bigel.) Beck
Spiranthes vernalis Engelm. & Gray
Spiranthes cernua var. *cernua* (L.) Richard
Spiranthes ovalis Lindl.
Corallorhiza wisteriana Conrad
Corallorhiza odontorhiza (Willd.) Nutt. f. *odontorhiza*
Malaxis unifolia Michx. f. *unifolia*
Liparis liliifolia (L.) Richard f. *liliifolia*
Aplectrum hyemale (Muhl.) Torr. f. *hyemale*
Hexalectris spicata (Walt.) Bernh.

PIPERALES
Saururaceae - Lizard's Tail Family

Saururus cernuus L.

SALICALES
Salicaceae - Willow Family

Salix nigra Marsh.
Salix caroliniana Michx.
Salix interior var. *interior* f. *interior* Rowlee
Salix rigida var. *rigida* f. *rigida* Muhl.
Salix humilis var. *hyporhysa* Fern.
Salix sericea f. *sericea* Marsh.
Populus alba L.
Populus deltoides Marsh.

Juglandaceae - Walnut Family

Juglans nigra f. *nigra* L.
Juglans cinerea L.
Carya illinoenis (Wang.) K. Koch
Carya cordiformis f. *cordiformis* (Wang.) K. Koch
Carya ovata f. *ovata*. (Mill.) K. Koch
Carya ovata f. *fraxinifolia* (Sarg.) Steyerm.
Carya laciniosa (Michx.) Loud.
Carya tomentosa var. *tomentosa* f. *tomentosa* Nutt.
Carya ovalis (Wang.) Sarg.

FAGALES
Corylaceae - Hazel Family

Corylus americana var. *americana* f. *americana* Walt.
Corylus americana var. *americana* f. *missouriensis* (A. DC.) Fern.

TABLE A2
FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Ostrya virginiana var. virginiana f. virginiana (Mill.) K. Koch
Ostrya virginiana var. lasia Fern.
Carpinus caroliniana var. virginiana (Marsh.) Fern.
Betula nigra L.
Alnus serrulata var. serrulata f. serrulata (Ait.) Willd.

Fagaceae - Beech Family

Quercus alba f. alba L.
Quercus alba f. latiloba (Sarg.) Palmer & Steyerm.
Quercus stellata var. stellata Wang.
Quercus lyrata f. lyrata Walt.
Quercus macrocarpa f. macrocarpa Michx.
Quercus bicolor Willd.
Quercus prinoides var. acuminata f. acuminata (Michx.) Gl.
Quercus prinoides var. acuminata f. alexanderi (Britt.) Steyerm.
Quercus imbricaria Michx.
Quercus phellos L. f. phellos
Quercus marilandica Muenchh.
Quercus velutina f. velutina Lam.
Quercus shumardii var. shumardii Buckl.
Quercus shumardii var. schneckii (Britt.)
Quercus palustris Muenchh.
Quercus rubra var. rubra L.

URTICALES
Ulmaceae - Elm Family

Ulmus americana L.
Ulmus alata Michx.
Ulmus rubra Muhl.
Celtis occidentalis var. occidentalis L.
Celtis tenuifolia var. tenuifolia Nutt.
Celtis tenuifolia var. georgiana (Small) Fern. & Schub.
Celtis laevigata var. laevigata Willd.

Moraceae - Mulberry Family

Morus rubra L.
Morus alba var. alba f. alba L.
Maclura pomifera (Raf.) Schneid.
Cannabis sativa L.
Humulus lupulus L.

Urticaceae - Nettle Family

Urtica dioica L. var. procera (Muhl.) Wedd.
Laportea canadensis (L.) Gaud.
Bochmeria cylindrica var. cylindrica (L.) Sw.
Pilea pumila (L.) Gray
Parietaria pensylvanica var. pensylvanica Muhl.

SANTALALES
Santalaceae - Sandalwood Family

Comandra richardsiana Fern.

ARISTOLOCHIALES
Aristolochiaceae - Birthwort Family

Asarum canadense L.
Aristolochia serpentaria var. serpentaria L.
Aristolochia tomentosa Sims

POLYGONALES
Polygonaceae - Buckwheat Family

Rumex patientia L.
Rumex acetosella L. var. acetosella

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC
RIVER BASIN
(continued)

Rumex *hastatulus* Baldw.
Rumex *verticillatus* L.
Rumex *mexicanus* Meisn.
Rumex *altissimus* Wood
Rumex *orbiculatus* Gray
Rumex *crispus* L.
Rumex *crispus* x *obtusifolius* L.
Rumex *obtusifolius* L.
Rumex maritimus L. var. *fueginus* (Phil.) Dusen
Rumex *pulcher* L.
Rumex *conglomeratus* Murr.
Polygonum *ramosissimum* Michx. f. *ramosissimum*
Polygonum *erectum* L.
Polygonum *aviculare* var. *aviculare* L.
Polygonum *aviculare* var. *littorale* (Link) W.D.J. Koch
Polygonum *tenue* Michx.
Polygonum *coccineum* var. *coccineum* f. *coccineum* Muhl.
Polygonum *bicorne* Raf.
Polygonum *pensylvanicum* var. *pensylvanicum* L.
Polygonum *pensylvanicum* var. *laevigatum* Fern. f. *laevigatum*
Polygonum *lapathifolium* L. var. *lapathifolium*
Polygonum *hydropiper* L.
Polygonum *cespitosum* Blume var. *longisetum* (De Bruyn) Stewart
Polygonum *persicaria* L. var. *persicaria*
Polygonum *punctatum* var. *punctatum* Ell.
Polygonum *punctatum* var. *confertiflorum* (Meisn.) Fassett
Polygonum *hydropiperoides* var. *hydropiperoides* f. *hydropiperoides* Michx.
Polygonum *hydropiperoides* var. *hydropiperoides* f. *strigosum* (Small) Stanford
Polygonum *hydropiperoides* var. *setaceum* (Baldw.) Gl.
Polygonum *sagittatum* L. var. *sagittatum* f. *sagittatum*
Polygonum *virginianum* var. *virginianum* L.
Polygonum *convolvulus* L. var. *convolvulus*
Polygonum *scandens* var. *scandens* L.
Polygonum *scandens* var. *cristatum* (Engelm. & Gray) Gl.
Polygonum *cuspidatum* Sieb. & Zucc.
Fagopyrum *sagittatum* Gilib.

CARYOPHYLLALES
Chenopodiaceae - Goosefoot Family

Cycloloma *atriplicifolium* (Spring.) Coult.
Kochia *scoparia* var. *scoparia* L.
Kochia *scoparia* var. *culta* Farw.
Chenopodium *pumilio* R.Br.
Chenopodium *botrys* L.
Chenopodium *ambrosioides* var. *ambrosioides* Aellen
Chenopodium *ambrosioides* var. *anthelminticum* (L.) Gray
Chenopodium *glaucum* var. *glaucum* L.
Chenopodium *glaucum* var. *salinum* (Standley) Boivin
Chenopodium *desiccatum* var. *leptophylloides* (Murr.) Wahl.
Chenopodium *standleyanum* Aellen
Chenopodium *gigantospermum* Aellen
Chenopodium *murale* L.
Chenopodium *urbicum* L.
Chenopodium *album* var. album L.
Chenopodium *album* var. *lanceolatum* (Muhl.) Coss & Germ.
Chenopodium *missouriense* Aellen
Chenopodium *berlandieri* var. *zschackei* (Murr.) Murr.
Chenopodium *bushianum* Aellen
Atriplex *hortensis* L.
Atriplex *patula* var. *patula* L.
Atriplex *patula* var. *hastata* (L.) Gray
Atriplex *rosea* L.
Atriplex *argentea* Nutt.
Monolepis *nuttalliana* [R & S] Greene
Coreospermum *hyssopifolium* L.

Amaranthaceae (Amaranth Family)

Celosia *argentea* var. *cristata* (L.) Ktze.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC
RIVER BASIN
(continued)

Amaranthus tuberculatus (Moq.) Sauer
Amaranthus tamariscinus Nutt.
Amaranthus palmeri S. Wats.
Amaranthus torreyi (Gray) Benth.
Amaranthus spinosus L.
Amaranthus caudatus L.
Amaranthus hybridus L.
Amaranthus retroflexus L.
Amaranthus powellii S. Wats.
Amaranthus albus var. albus L.
Amaranthus graecizans L.
Iresine rhizomatosa Standl.
Froelichia floridana (Nutt.) Moq. var. campestris (Small) Fern.
Froelichia gracilis (Hook.) Moq.

Nyctaginaceae - Four o'clock Family

Mirabilis nyctaginea (Michx.) MacM.
Mirabilis albida (Walt.) Heimerl
Boerhaavia erecta L.

Phytolaccaceae - Pokeweed Family

Phytolacca americana L.

Aizoaceae - Carpet-weed Family

Mollugo verticillata L.

Portulacaceae - Purslane Family

Portulaca oleracea L.
Portulaca mundula Johnston
Portulaca grandiflora Hook.
Claytonia virginica f. virginica L.
Talinum parviflorum Nutt.
Talinum calycinum Engelm.

Caryophyllaceae - Pink Family

Paronychia canadensis (L.) Wood
Paronychia fastigata var. fastigata (Raf.) Fern
Sagina decumbens (Ell.) T & G
Arenaria serpyllifolia var. serpyllifolia L.
Arenaria stricta Michx.
Arenaria patula var. patula f. pitcheri (Nutt.) Steyerm.
Arenaria patula var. patula f. media Steyerm.
Stellaria media (L.) Cyrillo var. media
Stellaria longifolia Muhl.
Cerastium vulgatum var. vulgatum f. vulgatum L.
Cerastium arvense L. var. villosum (Muhl.) Hollick & Britt f.
Oblongifolium (Torr.) Pennell
Cerastium nutans Raf.
Cerastium brachypodum (Engelm.) Robins.
Cerastium viscosum f. viscosum L.
Holosteum umbellatum L.
Agrostemma githago L.
Lychnis alba Mill.
Silene antirrhina f. antirrhina L.
Silene conoidea L.
Silene dichotoma Ehrh.
Silene cserei Baumg.
Silene cucubalus Wibel var. cucubalus
Silene stellata (L.) Ait. f.
Silene noctiflora L.
Silene virginica L.
Silene regia Sims
Saponaria officinalis L.
Saponaria vaccaria L.
Dianthus armeria L.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

RANALES
Ceratophyllaceae - Hornwort Family

Ceratophyllum demersum L.

Nymphaeaceae - Water Lily Family

Nuphar luteum subsp. macrophyllum (Small) Beal
Nymphaea odorata var. odorata f. odorata Ait.
Nelumbo lutea (Willd.) Pers
Brasenia schreberi Gmel.
Cabomba caroliniana Gray

Annonaceae - Custard Apple Family

Asimina triloba (L.) Dunal

Ranunculaceae - Crowfoot Family

Hydrastis canadensis L.
Cimicifuga racemosa (L.) Nutt. var. racemosa f. racemosa
Actaea pachypoda Ell.
Thalictrum dioicum L.
Thalictrum dasycarpum Fisch. & Lall. var. dasycarpum
Thalictrum dasycarpum var. hypoglaucum (Rydb.) Boivin
Thalictrum revolutum DC. f. revolutum
Aquilegia canadensis L.f. canadensis
Delphinium ajacis L.
Delphinium tricorne Michx. f. tricorne
Delphinium carolinianum var. crispum Perry
Isopyrum biternatum (Raf.) T. & G.
Ranunculus longirostris Godron
Ranunculus laxicaulis (T & G) Darby
Ranunculus pusillus Poir.
Ranunculus abortivus var. abortivus f. abortivus L.
Ranunculus micranthus var. micranthus Nutt.
Ranunculus micranthus var. delitescens (Greene) Fern.
Ranunculus harveyi f. harveyi (Gray) Britt.
Ranunculus harveyi f. pilosus (Benke) Palmer & Steyerm.
Ranunculus flabellaris f. flabellaris Raf.
Ranunculus sceleratus L. var. sceleratus f. sceleratus
Ranunculus recurvatus Poir. var. recurvatus f. recurvatus
Ranunculus acris L. var. acris
Ranunculus septentrionalis var. septentrionalis Poir
Ranunculus hispidus var. hispidus Michx.
Ranunculus hispidus var. marilandicus (Poir.) Benson
Ranunculus fascicularis var. fascicularis Muhl.
Ranunculus fascicularis var. apricus (Greene) Fern.
Ranunculus sardous Crantz
Ranunculus arvensis L.
Adonis aestivalis L. var. citrina Hoffm.
Myosurus minimus L.
Anemone virginiana f. virginiana L.
Anemone virginiana f. leucosepala Fern.
Anemone virginiana f. plena Palmer & Steyermark
Anemone canadensis L.
Hepatica nobilis Schreb. var. acuta (Pursh) Steyermark f. acuta
Anemonella thalictroides f. thalictroides (L.) Spach
Clematis virginiana f. virginiana L.
Clematis virginiana f. missouriensis (Rydb.) Fern.
Clematis dioscoreifolia Levl & Vaniot var. dioscoreifolia
Clematis pitcheri T. & G.
Clematis fremontii S. Wats. var. riehlii Erickson

Berberidaceae - Barberry Family

Podophyllum peltatum f. peltatum L.
Caulophyllum thalictroides (L.) Michx.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Menispermaceae - Moonseed Family

Menispermum canadense L.
Cocculus carolinus (L.) DC.
Calycocarpum lyoni (Pursh) Gray

Lauraceae - Laurel Family

Sassafras albidum var. *albidum* (Nutt.) Nees
Sassafras albidum var. *molle* (Raf.) Fern.
Lindera benzoin var. *benzoin* f. *benzoin* (L.) Blume
Lindera benzoin var. *pubescens* (Palmer & Steyerm.) Rehd.

PAPAVERALES

Papaveraceae - Poppy Family

Sanguinaria canadensis var. *canadensis* f. *canadensis* L.
Stylophorum diphyllum (Michx.) Nutt.
Argemone mexicana L.
Argemone albiflora Hornem. subsp. *albiflora*
Eschscholtzia californica Cham.

Fumariaceae - Fumitory Family

Dicentra cucullaria (L.) Bernh. f. *cucullaria*
Dicentra canadensis (Goldie) Walp.
Corydalis flavula (Raf.) DC.
Corydalis micrantha (Engelm.) Gray
Corydalis aurea Willd.
Corydalis montana Engelm.

Cruciferae - Mustard Family

Brassica hirta Moench
Brassica kaber (DC.) L. C. Wheeler var. *pinnatifida* (Stokes) L. C. Wheeler
Brassica nigra (L.) Koch
Brassica juncea var. *juncea* (L.) Coss
Brassica juncea var. *crispifolia* Bailey
Brassica rapa L.
Brassica napus L. var. *hapobrassica* (L.) Peterm.
Erucastrum gallicum (Willd.) O. E. Schulz
Raphanus raphanistrum L.
Raphanus sativus L.
Conringia orientalis (L.) Dumort.
Lepidium campestre (L.) R. Br.
Lepidium perfoliatum L.
Lepidium virginicum L. var. *virginicum*
Lepidium densiflorum Schrad. var. *densiflorum*
Cardaria draba (L.) Desv.
Cardaria pubescens (C.A. Mey.) Rollins var. *elongata* Rollins
Thlaspi arvense L.
Thlaspi perfoliatum L.
Capsella bursa-pastoris (L.) Medic. var. *bursa-pastoris*
Neslia paniculata (L.) Desv.
Berteroa incana (L.) DC.
Draba verna var. *verna* L.
Draba brachycarpa Nutt.
Draba reptans var. *reptans*
Draba cuneifolia Nutt. var. *cuneifolia*
Armoracia aquatica (Eat.) Wieg.
Cardamine bulbosa f. *bulbosa* (Schreb.) BSP.
Cardamine pensylvanica Muhl. var. *pensylvanica*
Cardamine parviflora L. var. *arenicola* (Britt.) O. E. Schulz
Dentaria laciniata Muhl.
Leavenworthia uniflora (Michx.) Britt.
Sibara virginica (L.) Rollins
Arabis lyrata var. *lyrata* f. *lyrata* L.
Arabis hirsuta var. *pycnocarpa* (M. Hopkins) Rollins
Arabis hirsuta var. *adpressipilis* (M. Hopkins) Rollins

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Arabis laevigata (Muhl.) Poir. var. *laevigata*
Arabis missouriensis var. *missouriensis* Greene
Arabis shortii var. *shortii* (Fern.) Gl.
Arabis shortii var. *phalacrocarpa* (M. Hopkins) Steyerm.
Arabis canadensis L.
Nasturtium officinale var. *officinale* R. Br.
Nasturtium officinale var. *siifolium* (Reichenb.) Koch
Rorippa sylvestris (L.) Bess.
Rorippa sinuata (Nutt.) Hitchc.
Rorippa sessiliflora (Nutt.) Hitchc.
Rorippa obtusa (Nutt.) Britt. var. *obtusa*
Rorippa islandica var. *fernaldiana* Butt. & Abbe
Rorippa islandica var. *hispida* (Desv.) Butt & Abbe
Barbarea vulgaris var. *arcuata* (Opiz) Fries
Iodanthus pinnatifidus (Michx.) Steud.
Chorispora tenella (Pall.) DC.
Erysimum capitatum (Dougl.) Greene
Erysimum cheiranthoides L.
Erysimum repandum L.
Sisymbrium officinale var. *officinale* (L.) Scop.
Sisymbrium officinale var. *leiocarpum* DC.
Sisymbrium altissimum L.
Sisymbrium loeselii L.
Arabidopsis thaliana (L.) Heyn.
Camelina microcarpa Andrz.
Camelina sativa (L.) Crantz
Descurainia sophia (L.) Webb

Capparidaceae - Caper Family

Cleome serrulata Pursh
Cleome houtteana Schlecht.
Polanisia dodecandra (L.) DC. subsp. *dodecandra* var. *dodecandra*

ROSALES
Crassulaceae - Stonecrop Family

Sedum telephium L.

Saxifragaceae - Saxifrage Family

Penthorum sedoides L.
Sullivantia renifolia Rosend.
Saxifraga virginiensis Michx. f. *virginiensis*
Saxifrage pensylvanica L. var. *forbesii* (Vasey) Engl. & Irmsch.
Heuchera americana var. *interior* Rosend., Butt. & Lak.
Heuchera americana var. *hirsuticaulis* (Wheelock) Rosend., Butt. & Lak.
Heuchera richardsonii var. *grayana* Rosend., Butt. & Lak.
Heuchera richardsonii var. *affinis* Rosend., Butt. & Lak.
Mitella diphylla L. f. *diphylla*
Hydrangea arborescens var. *arborescens* f. *arborescens* L.
Hydrangea arborescens var. *oblonga* T. & G. f. *oblonga*
Hydrangea arborescens var. *deamii* St. John f. *deamii*
Ribes cynosbati L. var. *cynosbati* f. *cynosbati*
Ribes missouriense var. *missouriense* Nutt.

Platanaceae - Plane Tree Family

Platanus occidentalis var. *occidentalis* f. *occidentalis* L.

Rosaceae - Rose Family

Physocarpus opulifolius (L.) Maxim var. *intermedius* (Rydb.) Robins.
Spiraea prunifolia Sieb. & Zucc. var. *plena* Schneid.
Aruncus dioicus (Walt.) Fern. var. *pubescens* (Rydb.) Fern.
Gillenia stipulata (Muhl.) Trel.
Pyrus communis L.
Pyrus malus L.
Pyrus coronaria var. *lancifolia* (Rehd.) Fern.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Pyrus ioensis (Wood) Bailey
Amelanchier arborea (Michx. f.) Fern.
Crataegus viridis var. *viridis* L.
Crataegus viridis var. *ovata* (Sarg.) Palmer
Crataegus viridis var. *lanceolata* (Sarg.) Palmer
Crataegus Atrorubens Ashe
Crataegus margaretta var. *margaretta* Ashe
Crataegus crus-galli var. *crus-galli* f. *crus-galli* L.
Crataegus crus-galli var. *barrettiana* (Sarg.) Palmer
Crataegus acutifolia Sarg. var. *acutifolia*
Crataegus vallicola Sarg.
Crataegus engelmanni var. *engelmanni* f. *engelmanni* Sarg.
Crataegus engelmanni var. *engelmanni* f. *nuda* Palmer
Crataegus fecunda Sarg.
Crataegus collina var. *collina* Chapm.
Crataegus collina var. *succincta* (Sarg.) Palmer
Crataegus kelloggii Sarg.
Crataegus pruinosa var. *pruinosa* (Wendl.) K. Koch
Crataegus disjuncta Sarg.
Crataegus mackenzii var. *mackenzii* Sarg.
Crataegus locuples Sarg.
Crataegus coccinioides Ashe
Crataegus calpodendron var. *calpodendron* (Ehrh.) Medic.
Crataegus calpodendron var. *globosa* (Sarg.) Palmer
Fragaria virginiana var. *illinoensis* (Prince) Gray
Potentilla simplex var. *simplex* Michx.
Potentilla simplex var. *calvescens* Fern.
Potentilla norvegica L. var. *norvegica*
Potentilla rivalis Nutt. var. *rivalis*
Potentilla rivalis var. *millegrana* (Engelm.) Wats.
Potentilla paradoxa Nutt.
Potentilla recta L.
Potentilla arguta Pursh
Geum vernum (Raf.) T. & G.
Geum canadense var. *camporum* (Rydb.) Fern & Weath
Rubus occidentalis L. f. occidentalis
Rubus trivialis Michx.
Rubus flagellaris var. *flagellaris Willd*.
Rubus flagellaris var. *occidualis* Bailey f. *occidualis*
Rubus Ensleni Tratt.
Rubus allegheniensis var. *allegheniensis* Porter
Rubus orarius Blanchard
Rubus mollior Bailey
Rubus pensilvanicus f. *pensilvanicus* Poir
Rubus ostryifolius Rydb.
Agrimonia parviflora Ait.
Agrimonia rostellata Wallr.
Agrimonia pubescens Wallr.
Rosa setigera var. *tomentosa* f. *tomentosa* T. & G.
Rosa eglanteria L.
Rosa carolina L. var. *carolina* f. *carolina*
Rosa carolina var. *carolina* f. *glandulosa* (Crepin) Fern.
Prunus mexicana S. Wats.
Prunus americana Marsh
Prunus hortulana Bailey
Prunus munsoniana Wight & Hedrick
Prunus serotina Ehrh.

Leguminosae - Pea Family

Desmanthus illinoensis (Michx.) MacM.
Desmanthus leptolobus T. & G.
Schrankia uncinata Willd.
Gymnocladus dioica (L.) K. Koch
Gleditsia triacanthos f. *triacanthos* L.
Gleditsia triacanthos f. *inermis* (Pursh) Schneid
Gleditsia aquatica Marsh.
Cassia marilandica L.
Cassia tora L.
Cassia fasciculata var. *fasciculata* f. *fasciculata* Michx.
Cassia fasciculata var. *fasciculata* f. *jenseni* Palmer and Steyerm.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Cassia *fasciculata* var. *robusta* (Pollard) Macbr.
Cassia *nictitans* L. var. *nictitans*
Cercis *canadensis* var. *canadensis* f. *canadensis* L.
Cercis *canadensis* var. *canadensis* f. *glabrifolia* Fern.
Baptisia *australis* (L.) R. Br. var. *minor* (Lehm.) Fern.
Baptisia *leucophaea* var. *leucophaea* Nutt.
Baptisia *leucantha* T. & G.
Baptisia *sphaerocarpa* Nutt.
Crotalaria *sagittalis* L. var. *sagittalis*
Trifolium *pratense* var. *pratense* f. *pratense* L.
Trifolium *incarnatum* L.
Trifolium *arvense* L.
Trifolium *resupinatum* L.
Trifolium *repens* f. *repens* L.
Trifolium *repens* f. *giganteum* Lagr.-Foss
Trifolium *hybridum* L. var. *pratense* Rabenh.
Trifolium *carolinianum* Michx.
Trifolium *stoloniferum* Eat.
Trifolium *reflexum* var. *reflexum*
Trifolium *reflexum* var. *glabrum* Lojacono
Trifolium *campestre* Schreb.
Trifolium *dubium* Sibth.
Medicago *sativa* L. f. *sativa*
Medicago *lupulina* var. *lupulina* L.
Medicago *lupulina* var. *glandulosa* Neilr.
Medicago *polymorpha* L. var. *vulgaris* (Benth.) Shinners f. *vulgaris* Rh.
Melilotus *officinalis* (L.) Lam.
Melilotus *albus* Desr.
Anthyllis *vulneraria* L.
Lotus *purshianus* Clements and Clements
Psoralea *onobrychis* Nutt.
Psoralea *psoralioides* (Walt.) Cory var. *eglandulosa* (Ell.) Freeman
Psoralea *tenuiflora* var. *tenuiflora* f. *tenuiflora* Pursh
Psoralea *esculenta* Pursh
Dalea *alopecuroides* Willd.
Petalostemon *candidum* (Willd.) Michx.
Petalostemon *purpureum* f. *purpureum* (Vent.) Rydb.
Amorpha *canescens* f. *canescens* Pursh
Amorpha *canescens* f. *glabrata* (Gray) Fassett
Amorpha *fruticosa* var. *fruticosa* L.
Tephrosia *virginiana* var. *virginiana* (L.) Pers.
Sesbania *exaltata* (Raf.) Cory
Robinia *pseudo-acacia* L.
Astragalus *distortus* T. & G.
Astragalus *canadensis* L. var. *canadensis*
Astragalus *mexicanus* A. DC. var. *trichocalyx* (Nutt.) Fern.
Glycyrrhiza *lepidota* (Nutt.) Pursh var. *lepidota*
Coronilla *varia* L.
Desmodium *nudiflorum* f. *nudiflorum* (L.) DC.
Demodium *glutinosum* (Muhl.) Wood f. *glutinosum*
Desmodium *pauciflorum* (Nutt.) DC.
Desmodium *rotundifolium* DC.
Desmodium *canescens* (L.) DC. f. *canescens*
Desmodium *illinoense* Gray
Desmodium *sessilifolium* (Torr.) T. & G.
Desmodium *rigidum* (Ell.) DC.
Desmodium *ciliare* (Muhl.) DC. var. *ciliare*
Desmodium *marilandicum* (L.) DC.
Desmodium *canadense* (L.) DC.
Desmodium *cuspidatum* var. *cuspidatum* (Muhl.) Loud.
Desmodium *cuspidatum* var. *longifolium* (T. & G.) Schub.
Desmodium *paniculatum* var. *paniculatum* (L.) DC.
Desmodium *paniculatum* var. *dillenii* (Darl.) Isely
Lespedeza *repens* (L.) Bart.
Lespedeza *procumbens* var. *procumbens* Michx.
Lespedeza *violacea* (L.) Pers.
Lespedeza *virginica* (L.) Britt.
Lespedeza *intermedia* (S. Wats.) Britt. f. *intermedia*
Lespedeza *manniana* Mackenz. & Bush

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Lespedeza stuevei var. *angustifolia* Britt.
Lespedeza capitata var. *capitata* Michx.
Lespedeza capitata var. *vulgaris* T. & G.
Lespedeza capitata var. *stenophylla* Bissel & Fern. f. *stenophylla*
Lespedeza hirta (L.) Hornem. var. *hirta*
Lespedeza striata (Thunb.) H. & A.
Lespedeza stipulacea Maxim.
Onobrychis viciaefolia Scop.
Stylosanthes biflora (L.) BSP.
Vicia sativa var. *nigra* L.
Vicia hirsuta (L.) S. F. Gray
Vicia villosa Roth f. *villosa*
Vicia dasycarpa Ten.
Vicia americana var. *americana* Muhl.
Lathyrus venosus Muhl. var. *intonsus* Butt. & St. John
Lathyrus hirsutus L.
Lathyrus latifolius L.
Pisum sativum L. var. *arvense* (L.) Poir.
Clitoria mariana L.
Apios americana var. *americana* f. *americana* Medic
Apios americana var. *turrigera* Fern.
Phaseolus polystachios (L.) BSP. var. *polystachios*
Strophostyles helvola var. *helvola* (L.) Ell.
Strophostyles helvola var. *missouriensis* (S. Wats.) Britt.
Strophostyles umbellata (Muhl.) Britt. var. *umbellata*
Strophostyles leiosperma (T. & G.) Piper
Glycine max (L.) Merr.
Amphicarpa bracteata var. *bracteata* (L.) Fern.
Amphicarpa bracteata var. *comosa* (L.) Fern.
Galactia volubilis (L.) Britt. var. *mississippiensis* Vail

GERANIALES

Linaceae - Flax Family

Linum usitatissimum L. var. *usitatissimum*
Linum sulcatum Riddell
Linum medium (Planch.) Britt. var. *texanum* (Planch.) Fern.
Linum striatum Walt.

Oxalidaceae - Wood Sorrel Family

Oxalis violacea var. *violacea* f. *violacea* L.
Oxalis corniculata L.
Oxalis dillenii subsp. *dillenii* Jacq.
Oxalis stricta L.

Geraniaceae - Geranium Family

Geranium maculatum L. f. *maculatum*
Geranium carolinianum var. *carolinianum* L.
Geranium carolinianum var. *confertiflorum* Fern.
Geranium dissectum L.
Geranium molle L.
Erodium texanum - Gray

Zygophyllaceae - Caltrop Family

Tribulus terrestris L.
Kallstroemia hirsutissima Vail

Rutaceae - Rue Family

Zanthoxylum americanum Mill. f. *americanum*
Ptelea trifoliata var. *trifoliata* f. *trifoliata* L.
Ruta graveolens L.

Simaroubaceae - Quassia Family

Ailanthus altissima (Mill.) Swingle

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Polygalaceae - Milkwort Family

Polygala sanguinea f. sanguinea L.
Polygala sanguinea f. albiflora (Wheelock) Millsp.
Polygala verticillata var. verticillata L.
Polygala verticillata var. isocycla Fern.

Euphorbiacae - Spurge Family

Phyllanthus caroliniensis Walt.
Croton glandulosus L. var. septentrionalis Muell. Arg.
Croton capitatus Michx. var. capitatus
Croton capitatus var. lindheimeri (Engelm. & Gray) Muell. Arg.
Croton monanthogynus Michx.
Crotonopsis elliptica Willd.
Acalypha ostryaefolia Riddell
Acalypha rhomboidea Raf. var. rhomboidea
Acalypha virginica L.
Acalypha gracilens var. monococca Engelm.
Ricinus communis L.
Euphorbia dentata f. dentata Michx.
Euphorbia heterophylla var. heterophylla L.
Euphorbia platyphylla L.
Euphorbia obtusata Pursh
Euphorbia cyparissias L.
Euphorbia commutata Engelm.
Euphorbia marginata Pursh
Euphorbia corollata var. corollata L.
Euphorbia serpens HBK.
Euphorbia maculata L.
Euphorbia supina Raf.
Euphorbia humistrata Engelm.
Euphorbia glyptosperma Engelm.

Callitrichaceae - Water Starwort Family

Callitriche terrestris Raf. emend. Torr.
Callitriche heterophylla Pursh emend. Darby var. heterophylla

SAPINDALES
Anacardiaceae - Cashew Family

Rhus typhina L. f. dissecta Rehd.
Rhus glabra L. var. glabra
Rhus copallina L. var. latifolia Engler
Rhus aromatica var. aromatica Ait.
Rhus aromatica var. serotina (Greene) Rehd.
Toxicodendron radicans (L.) Kuntze

Aquifoliaceae - Holly Family

Ilex decidua Walt.

Celastraceae - Staff-tree Family

Euonymus atropurpureus Jacq.
Celastrus scandens L.

Staphyleaceae - Bladder-nut Family

Staphylea trifolia L.

Aceraceae - Maple Family

Acer saccharum var. saccharum f. saccharum Marsh.
Acer saccharum var. saccharum f. glaucum (Schmidt) Pax
Acer saccharum var. saccharum f. rugelii (Pax) Palmer & Steyermark
Acer nigrum f. nigrum Michx.
Acer rubrum var. rubrum f. rubrum L.
Acer rubrum var. trilobum K. Koch

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Acer saccharinum L.
Acer negundo var. *negundo* L.

Hippocastanaceae - Horse Chestnut Family

Aesculus glabra var. *glabra* f. *pallida* (K. Koch) Fern.
Aesculus glabra var. *leucodermis* Sarg.

Balsaminaceae - Touch-me-not Family

Impatiens pallida f. *pallida* Nutt.
Impatiens capensis Meerb.

RHAMNALES
Rhamnaceae - Buckthorn Family

Rhamnus lanceolata var. *lanceolata* Pursh
Rhamnus lanceolata var. *glabrata* Gleason
Rhamnus caroliniana var. *caroliniana* Walt.
Rhamnus carliniana var. *mollis* Fern.
Ceanothus americanus var. *intermedius* (Pursh) K. Koch
Ceanothus americanus var. *pitcheri* T. & G.

Vitaceae - Grape Family

Ampelopsis cordata Michx.
Ampelopsis arborea (L.) Koehne
Parthenocissus quinquefolia f. *quinquefolia* (L.) Planch.
Vitis aestivalis var. *aestivalis* Michx.
Vitis aestivalis var. *argentifolia* (Munson) Fern.
Vitis cinerea Engelm.
Vitis palmata Vahl
Vitis riparia var. *riparia* Michx.
Vitis riparia var. *praecox* Engelm.
Vitis vulpina L.
Vitis rupestris f. *rupestris* Scheele
Vitis rupestris f. *dissecta* (Eggert) Fern.

MALVALES
Tiliaceae - Linden Family

Tilia americana var. *americana* L.
Tilia americana var. *neglecta* (Spach) Fosberg
Tilia heterophylia Vent.

Malvaceae - Mallow Family

Althaea rosea L.
Malva neglecta Wallr.
Callirhoe triangulata (Leavenw.) Gray
Callirhoe involucrata (T. & G.) Gray var. *involucrata* f. *involucrata*
Callirhoe alcaeoides (Michx.) Gray
Sphaeralcea angusta (Gray) Fern.
Sida spinosa L.
Abutilon theophrasti Medic.
Hibiscus lasiocarpos Cav.
Hibiscus militaris Cav.
Hibiscus trionum L.

PARIETALES
Hypericaceae - St. John's-wort Family

Ascyrum hypericoides var. *multicaule* (Michx.) Fern
Hypericum perforatum L.
Hypericum punctatum var. *punctatum* f. *punctatum* Lam.
Hypericum spathulatum (Spach.) Steud.
Hypericum sphaerocarpum var. *sphaerocarpum* Michx.
Hypericum mutilum var. *mutilum* L.
Hypericum drummondii (Grev. & Hook.) T. & G.
Hypericum gentianoides (L.) BSP.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Cistaceae - Rockrose Family

Helianthemum *bicknellii* Fern.
Lechea *villosa* Ell.
Lechea *tenuifolia* Michx. var. *tenuifolia*

Violaceae - Violet Family

Hybanthus *concolor* f. *concolor* (T.F. Forst) Spreng.
Viola *pedata* var. *pedata* L.
Viola *pedata* var. *lineariloba* DC. f. *lineariloba*
Viola *papilionacea* Pursh f. *papilionacea*
Viola *missouriensis* Greene
Viola *sororia* f. *sororia* Willd.
Viola *sagittata* Ait.
Viola *triloba* f. *triloba* Schwein.
Viola *triloba* f. *dilatata* (Ell.) Palmer & Steyerm.
Viola *viarum* f. *viarum* Pollard
Viola *pensylvanica* var. *pensylvanica* Michx.
Viola *pensylvanica* var. *leiocarpa* (Fern & Wieg.) Fern.
Viola *striata* Ait.
Viola *kitaibeliana* R. & S. var. *rafinesquii* (Greene) Fern.

Passifloraceae - Passion-flower Family

Passiflora *lutea* L. var. *glabriflora* Fern.

Loasaceae - Loasa Family

Mentzelia *oligosperma* Nutt.

CACTALES
Cactaceae - Cactus Family

Opuntia *compressa* (Salisb.) Macbr.

Elaeagnaceae - Oleaster Family

Elaeagnus *angustifolia* L.

MYRTALES
Lythraceae - Loosestrife Family

Peplis *diandra* Nutt.
Rolala *ramosior* var. *interior* Fern. & Grise.
Ammannia *coccinea* Rothb.
Lythrum *alatum* Pursh
Cuphea *petiolata* (L.) Koehn

Onagraceae - Evening Primrose Family

Jussiaea *repens* L. var. *glabrescens* Ktze.
Ludwigia *alternifolia* var. *alternifolia* L.
Ludwigia *alternifolia* var. *pubescens* Palmer & Steyerm.
Ludwigia *polycarpa* Short & Peter
Ludwigia *palustris* var. *americana* (DC.) Fern. & Grisc.
Epilobium *celoratum* Biehler
Oenothera *biennis* var. *biennis* L.
Oenothera *biennis* var. *pycnocarpa* (Atkinson & Bartlett) Wieg.
Oenothera *biennis* var. *hirsutissima* Gray
Oenothera *rhombipetala* Nutt.
Oenothera *laciniata* var. *laciniata* Hill
Oenothera *laciniata* var. *grandiflora* (S. Wats.) Robins.
Oenothera *serrulata* Nutt.
Oenothera *linifolia* Nutt.
Oenothera *pilosella* f. *pilosella* Raf.
Oenothera *fruticosa* L. var. *linearis* (Michx.) S. Wats.
Oenothera *kunthiana* (Spach) Munz
Oenothera *speciosa* Nutt.
Oenothera *missouriensis* Sims var. *missouriensis*

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Oenothera triloba Nutt.
Gaura biennis var. *biennis* L.
Gaura parviflora f. *parviflora* Doug.
Gaura parviflora f. *glabra* Munz
Gaura parviflora f. *lachnocarpa* Weath.
Gaura coccinea Pursh var. *coccinea*
Circaea quadrisulcata (Maxim.) Franch. & Sav. var. *canadensis* (L) Hara

Haloragidaceae - Water Milfoil Family

Myriophyllum heterophyllum Michx.
Proserpinaca palustris var. *palustris* L.
Proserpinaca palustris var. *crebra* Fern. & Grisc.

UMBELLALES
Araliaceae - Ginseng Family

Aralia spinosa L.
Aralia racemosa L.
Panax quinquefolius L.

Umbelliferae - Parsley Family

Sanicula gregaria Bicknell
Sanicula canadensis var. *canadensis* L.
Eryngium yuccifolium Michx. var. *yuccifolium*
Chaerophyllum procumbens var. *procumbens* (L.) Crantz
Chaerophyllum procumbens var. *shortii* T. & G.
Osmorhiza claytoni (Michx.) Clarke
Osmorhiza longistylis var. *longistylis* (Torr.) DC.
Osmorhiza longistylis var. *villicaulis* Fern.
Torilis japonica (Houtt.) DC.
Torilis nodosa (L.) Gaertn.
Erigenia bulbosa (Michx.) Nutt.
Conium maculatum L.
Spermolepis inermis (Nutt.) Math. & Const.
Bupleurum rotundifolium L.
Zizia aptera (Gray) Fern.
Zizia aurea (L.) Kock f. *aurea*
Cicuta maculata L. var. *maculata*
Cryptotaenia canadensis (L.) DC.
Taenidia integerrima (L.) Drude
Aegopodium podagraria L.
Perideridia americana (Nutt.) Reichenb.
Sium suave Walt. f. *suave*
Ptilimnium nuttalli (DC.) Britt.
Ptilimnium costatum (Ell.) Raf.
Cynosciadium pinnatum DC.
Foeniculum vulgare Mill.
Anethum graveoleus L.
Thaspium trifoliatum var. *flavum* Blake
Thaspium barbinode (Michx.) Nutt. var. *barbinode*
Oxypolis rigidior var. *rigidior* (L.) C. & R.
Polytaenia nuttallii DC.
Pastinaca sativa L.
Heracleum maximum Bartr.
Daucus carota L.
Daucus carota L. *carota* L.
Anthriscus scandicina (Weber) Mans.
Ammi majus L.

Cornaceae - Dogwood Family

Cornus florida f. *florida* L.
Cornus florida f. *rubra* (Weston) Palmer & Steyerm.
Cornus drummondi Meyer
Cornus obliqua Raf.
Cornus racemosa Lam.
Cornus alternitalia L. f.
Nyssa sylvatica var. *caroliniana* (Poir.) Fern.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

ERICALES
Pyrolaceae - Wintergreen Family

Monotropa uniflora L.
Monotropa Hypopithys L.

Ericaceae - Heath Family

Vaccinium arboreum var. glaucescens (Greene) Sarg.
Vaccinium vacillans var. vacillans var. vacillans Torr.
Vaccinium vacillans var. crinitum Fern.

Primulaceae - Primrose Family

Androsace occidentalis Pursh
Dodecatheon meadia var. meadia f. meadia L.
Dodecatheon meadia var. brachycarpum (Small) Fassett f. brachycarpum
Lysimachia nummularia L.
Lysimachia ciliata L.
Lysimachia lanceolata Walt.
Lysimachia hybrida Michx.
Lysimachia quadriflora f. quadriflora Sims
Anagallis arvensis f. arvensis L.
Anagallis arvensis f. caerulea (Schreb.) Baumg.
Centenculus minimus L.
Samolus parviflorus Raf.
Hottonia inflata Ell.

EBENALES
Sapotaceae - Sapodilla Family

Bumelia lanuginosa (Michx.) Pers. var. albicans Sarg.

Ebenaceae - Ebony Family

Diospyros virginiana var. virginiana L.
Diospyros virginiana var. pubescens (Pursh) Dippel f. pubescens
Diospyros virginiana var. platycarpa f. platycarpa Sarg.

GENTIANALES
Oleaceae - Olive Family

Fraxinus americana L. var. americana
Fraxinus pennsylvanica var. subintegerrima (Vahl.) Fern.
Fraxinus quadrangulata Michx.
Forestiera acuminata (Michx.) Poir

Gentianaceae - Gentian Family

Sabatia angularis f. angularis (L.) Pursh
Sabatia angularis f. albiflora (Raf.) House
Sabatia campestris Nutt.
Gentiana quinquefolia L. var. occidentalis (Gray) Hitchc.
Gentiana puberula Michx.
Gentiana andrewsii Griseb.
Gentiana flavida Gray
Swertia caroliniensis (Walt.) Kuntze
Nymphoides peltatum (Gmel.) Britten & Rendle

Apocynaceae - Dogbane Family

Amsonia tabernaemontana var. tabernaemontana Walt.
Amsonia tabernaemontana var. salicifolia (Pursh) Woodson
Amsonia tabernaemontana var. gattingeri Woodson
Amsonia illustris Woodson
Vinca minor L.
Apocynum androsaemifolium L. var. androsaemifolium
Apocynum cannabinum var. cannabinum L.
Apocynum cannabinum var. pubescens (Mitchell) A. DC.
Apocynum sibiricum var. sibiricum Jacq.

TABLE A2
FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Asclepiadaceae - Milkweed Family

Asclepias viridis Walt.
Asclepias viridiflora var. *viridiflora* Raf.
Asclepias viridiflora var. *lanceolata* (Ives) Torr.
Asclepias tuberosa var. *interior* (Woodson) Shinners f. *interior*
Asclepias tuberosa var. *interior* f. *lutea* (Clute) Steyerm.
Asclepias purpurascens L.
Asclepias incarnata var. *incarnata* f. *incarnata* L.
Asclepias quadrifolia Jacq.
Asclepias sullivantii Engelm.
Asclepias syriaca L. var. *kansana* (Vail)Palmer & Steyerm.
Asclepias amplexicaulis Sm.
Asclepias meadii Torr.
Asclepias verticillata L.
Asclepias stenophylla Gray
Asclepias hirtella (Pennell) Woodson
Cynanchum laeve (Michx.) Pers.
Matelea decipiens (Alex.) Woodson
Matelea obliqua (Jacq.) Woodson

POLEMONIALES
Convolvulaceae - Morning Glory Family

Evolvulus alsinoides L.
Evolvulus nuttallianus R. & S.
Ipomoea coccinea L.
Ipomoea hederacea var. *hederacea* (L.) Jacq.
Ipomoea hederacea var. *integriuscula* Gray
Ipomoea purpurea (L.) Roth
Ipomoea pandurata f. *pandurata* (L.) G.F.W. Mey.
Ipomoea pandurata f. *leviuscula* Fern.
Ipomoea lacunosa f. *lacunosa* L.
Ipomoea lacunosa f. *purpurata* Fern
Ipomoea cairica (L.) House
Convolvulus spithamaeus L. var. *spithamaeus*
Convolvulus sepium var. *sepium* f. *sepium* L.
Convolvulus sepium var. *fraterniflorus* Mackenz. & Bush
Convolvulus sepium var. *repens* (L.) Gray
Convolvulus pellitus Ledeb. f. *anestius* Fern.
Convolvulus arvensis f. *arvensis* L.
Convolvulus arvensis f. *cordifolius* L.
Cuscuta cuspidata Engelm.
Cuscuta glomerata Choisy
Cuscuta compacta Juss.
Cuscuta pentagona Engelm.
Cuscuta campestris Yuncker
Cuscuta indecora Choisy var. *neuropetala* (Engelm.) Hitchc.
Cuscuta gronovii Willd.
Cuscuta cephalanthi Engelm
Cuscuta coryli Engelm.
Cuscuta polygonorum Engelm.

Polemoniaceae - Phlox Family

Polemonium reptans L.
Phlox divaricata var. *laphamii* Wood f. *laphamii*
Phlox pilosa var. *pilosa* L.
Phlox pilosa var. *ozarkana* Wherry
Phlox glaberrima L. var. *interior* Wherry
Phlox paniculata f. *paniculata* L.
Phlox amplifolia Britt.

Hydrophyllaceae - Waterleaf Family

Hydrophyllum virginianum L. var. *virginianum*
Hydrophyllum canadense L.
Hydrophyllum appendiculatum Michx.
Ellisia nyctelea L.
Phacelia purshii Buckl.
Phacelia bipinnatifida Michx.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Boraginaceae - Borage Family

Heliotropium tenellum (Nutt.) Torr.
Heliotropium indicum L.
Symphytum officinale L.
Echium vulgare L. var. vulgare
Onosmodium occidentale Mackenz.
Onosmodium hispidissimum Mackenz.
Onosmodium subsetcsum Mackenz. & Bush
Lithospermum arvense L.
Lithospermum latifolium Michx.
Lithospermum incisum Lehm.
Lithospermum caroliniense (Walt.) MacM.
Lithospermum canescens f. canescens (Michx.) Lehm.
Cynoglossum officinale L.
Cynoglossum virginianum L.
Myosotis scorpioides L.
Myosotis virginica var. virginica (L.) BSP.
Myosotis virginica var. macrosperma (Engelm.) Fern
Amsinckia lycopsoides Lehm.
Amsinckia tessellata Gray
Mertensia virginica f. virginica (L.) Pers.
Lappula echinata Bilib.
Hackelia virginiana (L.)

Verbenaceae - Vervain Family

Verbena urticifolia L. var. urticifolia
Verbena x engelmanni Moldenke
Verbena hastata f. hastata L.
Verbena stricta f. stricta Vent.
Verbena simplex Lehm.
Verbena x moochina Moldenke
Verbena bracteata Lag. & Rodr.
Verbena x deamii Moldenke
Verbena x perriana Moldenke
Verbena canadensis f. canadensis (L.) Britt.
Lippia lanceolata Michx.

Labiatae - Mint Family

Isanthus brachiatus (L.) BSP. var. brachiatus
Trichostema dichotomum var. dichotomum L.
Teucrium canadense var. virginicum (L.) Eat.
Scutellaria ovata var. ovata Hill
Scutellaria ovata var. versicolor (Nutt.) Fern.
Scutellaria ovata var. rugosa (Wood) Fern.
Scutellaria incana var. incana Biehler
Scutellaria lateriflora f. lateriflora L.
Scutellaria nervosa var. calvifolia Fern.
Scutellaria parvula var. parvula Michx.
Scutellaria parvula var. leonardi (Epling) Fern.
Marrubium vulgare L.
Agastache nepetoides (L.) Ktze.
Nepeta cataria L.
Glechoma hederacea var. micrantha Moricand
Glechoma hederacea L. var. hederacea
Prunella vulgaris var. vulgaris f. vulgaris
Prunella vulgaris var. lanceolata (Bart.) Fern. f. lanceolata
Prunella vulgaris var. lanceolata f. iodocalyx Fern
Physostegia virginiana var. virginiana f. virginiana (L.) Benth.
Physostegia virginiana var. speciosa (Sweet) Gray
Physostegia angustifolia Fernald
Physostegia formosior Lunell
Leonurus cardiaca L.
Galeopsis tetrahit L. var. tetrahit
Lamium amplexicaule L. f. amplexicaule
Lamium purpureum L.
Stacys palustris var. phaneropoda Weath.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Stachys tenuifolia var. tenuifolia Willd.
Stachys hyssopifolia Michx. var. ambigua Gray
Salvia lyrata L.
Salvia azurea Lam. var. grandiflora Benth.
Salvia reflexa Hornem.
Monarda russeliana Nutt.
Monarda fistulosa var. fistulosa f. fistulosa L.
Monarda fistulosa var. mollis (L.) Benth.
Monarda citriodora Cerv.
Blephilia ciliata (L.) Benth. f. ciliata
Blephilia hirsuta (Pursh) Benth. var. hirsuta
Hedeoma pulegioides (L.) Pers.
Hedeoma hispida Pursh
Melissa officinalis L.
Satureja arkansana f. arkansana (Nutt.)Brig.
Satureja arkansana f. alba Steyermark
Pyenanthemum tenuifolium Schrad.
Pyenanthemum virginianum (L.) Durand & Jackson
Pyenanthemum pilosum Nutt.
Cunila origanoides (L.) Britt.
Lycopus virginicus L.
Lycopus americanus var. americanus Muhl.
Lycopus rubellus var. rubellus Moench
Lycopus rubellus var. arkansanus (Fresn.) Benner
Lycopus rubellus var. lanceolatus Benner
Mentha arvensis var. villosa (Benth.) Stewart f. villosa
Mentha arvensis var. villosa f. glabrata (Benth.) Stewary
Mentha spicata L.
Mentha piperita L.
Perilla frutescens var. frutescens (L.) Britt.
Dracocephalum parviflorum Nuttall

Solanaceae - Nightshade Family

Solanum villosum Miller
Solanum dulcamara L. var. dulcamara f. dulcamara
Solanum americanum Mill.
Solanum carolinense f. carolinense L.
Solanum torreyi Gray f. torreyi
Solanum elaeagnifolium Cav. f. elaeagnifolium
Solanum rostratum Dunal
Lycopersicon esculentum Mill.
Physalis pumila Nutt.
Physalis heterophylla Nees var. heterophylia
Physalis virginiana Mill.
Physalis longifolia var. longifolia Nutt.
Physalis longifolia var. subglabrata (Mackenz. & Bush) Steyermark f. subglabrata
Physalis angulata var. angulata
Physalis angulata var. pendula (Rydb.) Waterfall
Physalis pubescens var. pubescens
Physalis pubescens var. glabra (Michx.) Waterfall
Physalis pubescens var. integrifolia (Dunal) Waterfall
Physalis pubescens var. grisea Waterfall
Physalis missouriensis Mackenz. & Bush
Nicandra physalodes (L.) Pers.
Lycium halimifolium Mill.
Datura stramonium var. straminium f. stramonium L.
Datura stramonium var. stramonium f. stramonium L.
Datura stramonium var. tatula (L.) Torr.
Datura innoxia Mill.
Nicotiana rustica L.
Petunia axillaris (Lam.) BSP.
Petunia violacea Lindl.

Scrophulariaceae - Figwort Family

Bacopa rotundifolia (Michx.) Wettst.
Gratiola neglecta Torr. var. neglecta
Conobea multifida (Michx.) Benth

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN (continued)

Mimulus ringens var. *ringens* L.
Mimulus alatus f. *alatus* Ait.
Mazus japonicus (Thunb.) Ktze.
Lindernia anagallidea (Michx.) Pennell
Lindernia dubia var. *dubia* (L.) Pennell
Lindernia dubia var. *riparia* (Raf.) Fern.
Verbascum thapsus L. f. *thapsus* Mullein
Verbascum blattaria f. *blattaria* L.
Verbascum blattaria f. *erubescens* Brugger
Chelone glabra var. *glabra* f. *glabra* L.
Chelone glabra var. *glabra* f. *tomentosa* (Raf.) Pennell
Penstemon digitalis f. *digitalis* Nutt.
Penstemon pallidus Small
Scrophularia marilandica f. *marilandica* L.
Scrophularia marilandica f. *neglecta* (Rydb.) Pennell
Collinsia verna Nutt.
Collinsia violacea f. *violacea* Nutt.
Linaria vulgaris Hill f. *vulgaris*
Linaria canadensis var. *canadensis* f. *canadensis* (L.) Dumort.
Linaria canadensis var. *texana* (Scheele) Pennell
Kickxia elatine (L.) Dumort.
Cymbalaria muralis Gaertn.
Antirrhinum majus L.
Veronicastrum virginicum (L.) Farw. f. *virginicum*
Veronica comosa Richter
Veronica peregrina var. *peregrina* L.
Veronica peregrina var. *xalapensis* (HBK.) Pennell
Veronica arvensis L.
Veronica polita Fries
Seymeria macrophylla Nutt.
Gerardia tenuifolia var. *tenuifolia* Vahl
Gerardia tenuifolia var. *macrophylla* Benth.
Gerardia auriculata Michx.
Gerardia grandifloria var. *pulchra* (Pennell) Fern.
Gerardia pedicularia var. *pectinata* Nutt.
Buchnera americana L.
Pedicularis canadensis f. *canadensis* L.
Castilleja coccinea f. *coccinea* (L.) Spreng.

Bignoniaceae - Trumpet Creeper Family

Campsis radicans (L.) Seem.
Catalpa bignonioides Walt.
Catalpa speciosa Warder

Martyniaceae - Unicorn Plant Family

Proboscidea louisianica (Mill.) hell.

Orobanchaceae - Broom-rape Family

Orobanche ludoviciana Nutt.
Orobanche uniflora L.

Lentibulariaceae - Bladderwort Family

Utricularia gibba L.
Utricularia vulgaris L.

Acanthaceae - Acanthus Family

Ruellia strepens f. *atrepens* L.
Ruellia strepens f. *cleistantha* (Gray) McCoy
Ruellia pedunculata f. *pedunculata* Torr.
Ruellia humilis var. *humilis* f. *humilis* Nutt.
Ruellia humilis var. *frondosa* Fern.
Ruellis humilis var. *longiflora* (Gray) Fern. f. *longiflora*
Ruellis humilis var. *expansa* Fern.
Justicia americana (L.) Vahl
Dicliptera brachiata (Pursh) Spreng.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Phrymaceae - Lopseed Family

Phryma leptostachya L. var. *leptostachya*

Plantaginaceae - Plantain Family

Plantago cordata Lam.
Plantago rugelii Dcne. var. *rugelii* Rugel
Plantago lanceolata var. *lanceolata* L.
Plantago lanceolata var. *sphaerostachya* Mert. & Koch f. sphaerostachya
Plantago aristata Michx.
Plantago purshii R. & S.
Plantago virginica L. var. *virginica*
Plantago pusilla var. *pusilla* Nutt.
Plantago heterophylla Nutt.
Plantago wrightiana Dcne.

RUBIALES

Rubiaceae - Madder Family

Galium virgatum Nutt.
Galium aparine L.
Galium triflorum Michx. var. *triflorum*
Galium pilosum var. *pilosum* Ait.
Galium pilosum var. *puncticulosum* (Michx.) T. & G.
Galium circaezans var. *circaezans* Michx.
Galium obtusum Bigel. var. *obtusum*
Galium concinnum T. & G.
Spermacoce glabra Michx.
Diodia teres Walt. var. *teres*
Mitchella repens L. f. *repens*
Cephalanthus occidentalis var. *occidentalis* f. *occidentalis* L.
Houstonia pusilla f. *pusilla* Schoepf
Houstonia minima Beck f. *minima*
Houstonia purpurea var. *calycosa* Gray
Houstonia longifolia Gaertn. var. *longifolia*
Houstonia nigricans (Lam.) Fern.

Caprifoliaceae - Honeysuckle Family

Lonicera morrowi Gray
Lonicera japonica Thunb. var. *japonica*
Lonicera sempervirens L. var. *sempervirens*
Lonicera flava var. *flava* Sims
Symphoricarpos orbiculatus Moench f. *orbiculatus*
Triosteum perfoliatum L.
Triosteum angustifolium var. *angustifolium* L.
Viburnum prunifolium L.
Viburnum rufidulum Raf.
Sambucus canadensis var. *canadensis* f. *canadensis* L.

Valerianaceae - Valerian Family

Valerianella radiata var. *radiata* (L.) Dufr.
Valerianella radiata var. *missouriensis* Dyal

Dipsacaceae - Teasel Family

Dipsacus sylvestris Huds. f. *sylvestris*

Cucurbitaceae - Gourd Family

Cucurbita foetidissima HBK.
Cucurbita pepo L. var. *ovifera* (L.) Alef.
Lagenaria siceraria (Molina) Standl.
Citrullus vulgaris Schrad. var. *vulgaris*
Cucumis melo L. var. *melo*
Echinocystis lobata (Michx.) T. & G.
Sicyos angulatus L.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

CAMPANULALES
Campanulaceae - Bellflower Family

Campanula americana L.
Specularia perfoliata f. perfoliata (L.) A. DC.
Specularia leptocarpa (Nutt.) Gray
Lobelia inflata L.
Lobelia spicata var. spicata Lam.
Lobelia spicata var. hirtella Gray
Lobelia spicata var. leptostachys (A. DC.) Mackenz. & Bush.
Locelia siphilitica var. siphilitica f. siphilitica L.
Lobelia siphilitica var. ludoviciana A. DC.
Lobelia cardinalis f. cardinalis L.

Compositae - Composite Family

Vernonia crinita Raf.
Vernonia altissima var. altissima f. altissima Nutt.
Vernonia altissima var. taeniotricha Blake
Vernonia missurica Raf. f. missurica
Vernonia baldwini Torr. var. baldwini f. baldwini
Vernonia baldwini var. interior Schubert
Elephantopus carolinianus Willd. f. carolinianus
Eupatorium purpureum L.
Eupatorium altissimum L.
Eupatorium sessilifolium L. var. brittonianum Porter
Eupatorium perfoliatum var. perfoliatum f. perfoliatum L.
Eupatorium perfoliatum var. cuneatum Engelm.
Eupatorium serotinum Michx.
Eupatorium rugosum var. rugosum f. rugosum Houtt
Eupatorium rugosum var. tomentellum (Robins.) Blake
Eupatorium coelestinum L. f. coelestinum
Eupatorium capillifolium (Lam. Small
Brickellia grandiflora (Hook.) Nutt.
Kihnia eupatorioides var. eupatorioides L.
Kihnia eupatorioides var. corymbulosa T. & G.
Liatris pycnostachya f. pycnostachya Michx.
Liatris aspera f. aspera Michx.
Liatris ligulistylis (Nels.) K. Schum.
Liatris cylindracea Michx. f. cylindracea
Liatris squarrosa var. squarrosa (L.) Michx.
Grindelia squarrosa var. squarrosa (Pursh) Dunal
Grindelia squarrosa var. serrulata (Rydb.) Steyerm.
Grindelia squarrosa var. nuda (Wood) Gray
Gutierrezia dracunculoides (DC.) Blake
Gutierrezia texana (DC.) T. & G.
Heterotheca latifolia Buckley
Chrysopsis villosa var. camporum (Greene) Cron.
Solidago flexicaulis L.
Solidago petiolaris var. petiolaris Ait.
Solidago petiolaris var. wardii (Britt.) Fern.
Solidago hispida Muhl. var. hispida
Solidago speciosa var. speciosa Nutt.
Solidago speciosa var. angustata T. & G.
Solidago missouriensis var. missouriensis Nutt.
Solidago missouriensis var. fasciculata Holzinger
Solidago gattingeri Chapm.
Solidago juncea Ait. f. juncea
Solidago nemoralis var. nemoralis Ait.
Solidago nemoralis var. decemflora (DC.) Fern.
Solidago radula var. radula Nutt.
Solidago radula var. laeta (Greene) Fern.
Solidago ulmifolia var. ulmifolia Muhl.
Solidago rugosa var. rugosa Ait.
Solidago rugosa var. aspera Ait.
Solidago drummondii T. & G.
Solidago altissima L.
Solidago gigantea var. gigantea Ait.
Solidago gigantea var. leiophylla Fern.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Solidago rigida L. var. rigida
Haplopappus ciliatus (Nutt.) DC.
Boltonia asteroides var. recognita (Fern. & Grisc.) Cron.
Boltonia asteroides var. decurrens (T. & G.) Fern. & Grisc.
Aster furcatus Burgess
Aster anomalus f. anomalus Engelm.
Aster azureus var. azureus f. azureus Steyerm.
Aster azureus var. azureus f. laevicaulis Fern.
Aster cordifolius var. cordifolius L.
Aster sagittifolius f. sagittifolius Wedemeyer
Aster sagittifolius f. hirtellus (Lindl.) Shinners
Aster drummondii Lindl.
Aster patens var. patentissimus (Lindl.) T. & G.
Aster oblongifolius var. angustatus Shinners
Aster novae-angliae L. f. novae-angliae
Aster sericeus Vent. f. sericeus
Aster commutatus (T. & G.) Gray
Aster laevis var. laevis f. laevis L.
Aster laevis var. laevis f. latifolius (Porter) Shinners
Aster turbinellus Lindl.
Aster pilosus var. pilosus f. pilosus Willd.
Aster pilosus var. platyphyllus (T. & G.) Blake
Aster pilosus var. demotus Blake
Aster ericoides f. prostratus (Kuntze) Fern.
Aster vimineus var. subdumosus Wieg.
Aster lateriflorus (L.) Britt. var. lateriflorus
Aster ontarionis Wieg.
Aster praealtus var. praealtus Poir
Aster simplex var. ramosissimus (T. & G.) Cron.
Aster ptarmicoides (Nees.) T. & G. White
Aster linariifolius L. var. linariifolius f. linariifolius
Erigeron pulchellus Michx. var. pulchellus
Erigeron philadelphicus L. f. philadelphicus
Erigeron annuus (L.) Pers. f. annuus (L.) Pers.
Erigeron strigosus var. strigosus f. strigosus Muhl.
Erigeron tenuis T. & G.
Erigeron canadensis L.
Erigeron divaricatus Michx.
Antennaria neglecta var. neglecta Greene
Antennaria plantaginifolia var. plantaginifolia (L.) Hook
Antennaria plantaginifolia var. ambingens (Greene) Cron.
Gnaphalium purpureum L.
Gnaphalium obtusifolium var. obtusifolium L.
Iva ciliata var. ciliata Willd.
Iva xanthifolia Nutt.
Ambrosia bidentata Michx.
Ambrosia trifida var. trifida f. trifida L.
Ambrosia trifida var. trifida f. integrigolia (Muhl.) Fern.
Ambrosia trifida var. texana Scheele
Ambrosia artemisiifolia var. elatior (L.) Descourt. f. elatior
Ambrosia coronopifolia T. & G.
Franseria discolor Nutt.
Xanthium spinosum L. var. spinosum
Xanthium inflexum Mackenz. & Bush
Xanthium chinense Mill.
Xanthium pensylvanicum Wallr.
Xanthium italicum Moretti
Xanthium varians Greene
Polymnia canadensis f. canadensis L.
Polymnia canadensis f. radiata (Gray) Fassett
Polymnia uvedalia var. densipilis Blake
Silphium perfoliatum f. perfoliatum L.
Silphium integrifolium var. integrifolium f. integrifolium Michx.
Silphium integrifolium var. laeve T. & G.
Silphium laciniatum L. var. laciniatum
Silphium terebinthinaceum Jacq. var. terebinthinaceum
Parthenium integrifolium L. var. integrifolium
Parthenium hispidum Raf.
Heliopsis helianthoides var. scabra (Dunal) Fern.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Eclipta alba (L.) Hassk.
Rudbeckia laciniata L. var. laciniata L. var. laciniata
Rudbeckia subtomentosa f. subtomentosa Pursh
Rudbeckia subtomentosa f. craigii (Sherff) Fern.
Rudbeckia grandifloria (D. Don) DC. var. grandifloria
Rudbeckia hirta L.
Rudbeckia missouriensis Engelm.
Rudbeckia triloba L. var. triloba
Echinacea purpurea var. purpurea f. purpurea (L.) Moench
Echinacea pallida f. pallida Nutt.
Ratibida pinnata (Vent.) Barnh.
Ratibida columnifera f. columnifera (Nutt.) Woot & Standl.
Ratibida columnifera f. pulcherrima (DC.) Fern.
Helianthus annuus var. annuus L.
Helianthus annuus var. annuus 'Florepleno' Hort.
Helianthus petiolaris Nutt.
Helianthus laetiflorus var. laetiflorus Pers.
Helianthus laetiflorus var. rigidus (Cass.) Fern.
Helianthus occidentalis Riddell var. occidentalis
Helianthus mollis f. mollis Lam.
Helianthus divaricatus L. var. divaricatus
Helianthus hirsutus var. hirsutus Raf.
Helianthus maximiliani Schrad.
Helianthus strumosus L.
Helianthus tuberosus var. tuberosus L.
Helianthus tuberosus var. subcanescens Gray
Helianthus grosseserratus f. grosseserratus Martens
Verbesina virginica L.
Verbesina helianthoides Michx.
Verbesina alfernifolia (L.) Britt.
Verbesina encelioides (Cav.) B. S. H. var. exauricalata Robins. & Granm.
Coreopsis cardaminefolia (DC.) T. & G.
Coreopsis grandiflora var. grandiflora Hogg
Coreopsis lanceolata var. lanceolata L.
Coreopsis lanceolata var. villosa Michx.
Coreopsis pubescens Ell. var. pubescens
Coreopsis palmata Nutt.
Coreopsis tripteris var. tripteris L..
Coreopsis tripteris var. deamii Standl.
Bidens cernua var. cernua f. cernua L.
Bidens connata Muhl. var. petiolata (Nutt.) Farw.
Bidens comosa (Gray) Wieg.
Bidens vulgata var. vulgata f. vulgata Greene
Bidens frondosa L. var. frondosa f. frondosa
Bidens discoidea (T. & G.) Britt.
Bidens aristosa var. aristosa (Michx.) Britt.
Bidens aristosa var. fritcheyi Fern.
Bidens aristosa var. mutica Gray
Bidens polylepis var. polylepis Blake
Bidens bipinnata L.
Cosmos bipinnatus Cav.
Galinsoga ciliata (Raf.) Blake
Helenium amarum (Raf.) H. Rock
Helenium flexuosum Raf.
Helenium autumnale var. canaliculatum (Lam.) T. & G.
Helenium autumnale var. parviflorum (Nutt.) Fern.
Gaillardia pulchelia Foug.
Dyssodia papposa (Vent.) Hitchc.
Tagetes erecta L.
Achillea millefolium L. subsp. millefolium var. millefolium f. millefolium
Achillea millefolium subsp. lanulosa (Nutt.) Piper
Anthemis tinctoria L.
Anthemis arvensis var. arvensis L.
Anthemis arvensis var. agrestis (Wallr.) DC.
Anthemis cotula L.
Matricaria maritima L. var. agrestis (Knaf) Wilmott
Matricaria chamomilla L. var. chamomilla
Matricaria matricarioides (Less.) Porter
Chrysanthemum leucanthemum var. leucanthemum L.
Chrysanthemum leucanthemum var. pinnatifidum LeCoq & Lamotte f. pinnatifidum

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Tanacetum *vulgare* f. *vulgare*
Artemisia *caudata* Michx. var. *caudata*
Artemisia *biennis* Willd.
Artemisia *vulgaris* L. var. *latiloba* Ledeb.
Artemisia *vulgaris* var. *vulgaris* L.
Artemisia *vulgaris* var. *glabra* Ledeb.
Artemisia *ludoviciana* var. *ludoviciana* Nutt.
Artemisia *ludoviciana* var. *gnaphalodes* (Nutt.) T. & G.
Artemisia *ludoviciana* var. *mexicana* (Willd.) Fern
Erechtites *hieracifolia* (L.) Raf. var. *hieracifolia*
Cacalia *suaveolens* L.
Cacalia *muhlen-ergii* (Sch. Bip.) Fern.
Cacalia *atriplicifolia* L.
Cacalia *tuberosa* Nutt.
Senecio *ampulloceus* Hook.
Senecio *vulgaris* L.
Senecio *glabellus* Poir
Senecio *plattensis* Nutt.
Senecio *aureus* var. aureus L.
Senecio *obovatus* Muhl.
Arctium *minus* (Hill) Bernh. f. *minus*
Carduus *nutans* L.
Carduus *crispus* L.
Cirsium *vulgare* (Savi) Tenore
Cirsium *undulatur* (Nutt.) Spreng. var. *megacephalum* (Gray) Fern.
Cirsium *discolor* f. *discolor* (Muhl.) Spreng.
Cirsium *discolor* f. *albiflorum* (Britt.) House
Cirsium *altissimum* f. *altissimum* (L.) Spreng.
Cirsium *carolinianum* (Walt.) Fern. & Schrub.
Cirsium *muticum* Michx. var. *muticum* f. *muticum*
Cirsium *arvense* (L.) Scop. var. *arvense* f. *arvense*
Centaurea *solstitialis* L.
Centaurea *cyanus* L.
Centaurea *nigra* L. var. *nigra*
Centaurea *vochinensis* Bernh.
Centaurea *maculosa* Lam.
Centaurea *americana* Nutt.
Centaurea *diffusa* Lam.
Serinia *oppositifolia* (Raf.) Ktze.
Cichorium *intybus* f. *intybus* L.
Krigia *virginica* (L.) Willd.
Krigia *dandelion* (L.) Nutt.
Krigia *biflora* (Walt.)lake
Hypochaeris *radicata* L.
Picris *sprengeriana* Poir.
Thelesperma *ambiguum* Gray
Tragopogon *porrifolius* L.
Tragopogon *dubius* Scop.
Tragopogon *pratensis* L.
Taraxacum *erythrospermum* Andrz.
Taraxacum *officinale* Wiggers
Sonchus *arvensis* var. *glabrescens* Guenth., Grab. & Winn.
Sonchus *oleraceus* L. f. *oleraceus*
Sonchus *asper* f. *asper* (L.) Hill
Lactuca *scariola* f. *scariola* L.
Lactuca *scariola* f. *integrifolia* (Bogenh.) G. Beck
Lactuca *saligna* f. *saligna* L.
Lactuca *canadensis* var. *canadensis* f. *canadensis* L.
Lactuca *canadensis* var. *canadensis* f. *angustata* Wieg.
Lactuca *canadensis* var. *obovata* Wieg. f. *obovata*
Lactuca *canadensis* var. *longifolia* Ktze. f. *latifolia* Wieg.
Lactuca *hirsuta* var. *sanguinea* (Bigel.) Fern
Lactuca *floridana* var. *floridana* f. *floridana* (L.) Gaertn.
Lactuca *floridana* var. *villosa* (Jacq.) Cronq.
Crepis *pulchra* L.
Crepis *capillaris* (L.) Wallr.
Crepis *tectorum* L.
Pyrrhopappus *carolinianus* (Walt.) DC.
Prenanthes *crepidinea* Michx.

TABLE A2

FLORAL ELEMENTS OF THE LOWER MERAMEC RIVER BASIN (continued)

Prenanthes racemosa Michx.
Prenanthes aspera Michx.
Prenanthes alba L.
Prenanthes altissima L. var. *cinnamomea* Fern.
Hieracium scabrum var. *scabrum* Michx.
Hieracium gronovii L.
Hieracium longipilum f. *longipilum* Torr.

SOURCE: (014)

TABLE A3
WILD MAMMALS OF THE LOWER MERAMEC RIVER BASIN

MARSUPIALIA - Pouched mammals	
Didelphidae - Opossoms	
Didelphis marsupialis Linnaeus	Opossum
INSECTIVORA - Insect eating mammals	
Soricidae - Shrews	
Blarina brevicauda (Say)	Short-tailed shrew
Cryptotis parva (Say)	Least shrew
Talpidae - Moles	
Scalopus aquaticus (Linnaeus)	Eastern mole
CHIROPTERA - Flying Mammals	
Vespertilionidae - Evening bats	
Myotis lucifugus (Le Conte)	Little brown bat
Myotis grisescens Howell	Gray bat
Myotis keenii (Merriam)	Keen's bat
Myotis sodalis Miller and G. M. Allen	Indiana bat
M. leibii (Audubon & Bachman)	Least bat
Lasionycteris noctivagans (Le Conte)	Silver-haired bat
Eptesicus fucus (Beauvois)	Big brown bat
Lasiurus borealis (Muller)	Red bat
Lasiurus cinereus (Beauvois)	Hoary bat
Nycticeius humeralis (Rafinesque)	Evening bat
Plecotus townsendii (Cooper)	Western lump-nosed bat
Plecotus rafinesquii (Audubon & Bachman)	Eastern lump-nosed bat
Pipistrellus subflavus	Eastern pipistrelle
LAGOMORPHA - Hare-shaped mammals	
Leporidae - Hares and rabbits	
Sylvilagus floridanus (J. A. Allen)	Eastern cottontail rabbit
RODENTIA - Gnawing mammals	
Sciuridae - Squirrels	
Marmota monax (Linnaeus)	Woodchuck
Tamias striatus (Linnaeus)	Eastern chipmunk
Sciurus carolinensis Gmelin	Eastern gray squirrel
Sciurus niger (Linnaeus)	Eastern fox squirrel
Glaucomys volans (Linnaeus)	Southern flying squirrel
Geomidae - Pocket gophers	
Geomys bursarius (Shaw)	Plains pocket gopher
Castoride - Beavers	
Castor canadensis Kuhl	Beaver
Cricetidae - Cricetid rats and mice	
Reithrodontomys megalotis (Baird)	Western harvest mouse

TABLE A3

WILD MAMMALS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Petomyscus maniculatus (Wagner)	Prairie white-footed mouse
Petomyscus leucopus (Rafinesque)	Woodland White-footed mouse
Petomyscus nutalii (Harlan)	Golden mouse
Sigmodon hispidus Say and Ord	Common cotton rat
Neotoma floridana (Ord)	Eastern wood rat
Synaptomys cooperi Baird	Southern hemming mouse
Microtus ochrogaster (Wagner)	Prairie vole
Microtus pinetorum (Le Conte)	Pine vole
Onadatra zibethicus (Linnaeus)	Muskrat
Muridae - Old world rats and mice	
Rattus norvegicus (Berkenhout)	Norway rat
Rattus rattus (Linnaeus)	Black rat
Mus musculus Linnaeus	House mouse
Zapidae - Jumping mouse	
Zapus hudsonius (Zimmermann)	Meadow jumping mouse
CARNIVORA - Flesh-eating mammals	
Canidae - Dogs, foxes and allies	
Canis latrans Say	Coyote
Canis niger (Bartram) (a)	Red wolf
Vulpes fulva (Desmarest)	Red fox
Urocyon cinercoargenteus (Schreber)	Gray fox
Ursidae - Bears	
Ursus americanus Pallas (a)	Black bear
Procyonidae - Raccoons	
Procyon lotor (Linnaeus)	Raccoon
Mustelidae - Weasels	
Mustela frenata Lichenstein	Long-tailed weasel
Mustela vison Schreber	Mink
Taxidea taxus (Schreber)	Badger
Spilogale putorius (Linnaeus)	Spotted skunk
Mephitis mephitis (Schreber)	Striped skunk
Lutra canadensis (schreber)	River otter
Felidae - Cats	
Lynx rufus (Schreber)	Bobcat
ARTIODACTYLA - Eventoed hoofed mammals	
Cervidae - Deer	
Odocoileus virginianus (Zimmermann)	White-tailed deer

NOTES: (a) Questionnable occurrence in study area

SOURCE: (021)

TABLE A4
AMPHIBIANS OF THE LOWER MERAMEC RIVER BASIN

CAUDATA - Salamanders and Allies	
Proteidae	
Necturus maculosus maculosus (Rafinesque)	Mudpuppy
Cryptobranchidae	
Cryptobranchus alleganiensis alleganiensis (Daudin)	Hellbender
Salamandridae	
Notophthalmus viridescens louisianensis (Wolterstorff)	Common newt
Ambystomidae	
Ambystoma annulatum (Cope)	Ringed salamander
A. maculatum (Shaw)	Spotted salamander
A. opacum (Gravenhorst)	Marbled salamander
A. texanum (Matthes)	Small-mouthed salamander
A. tigrinum tigrinum (Green)	Eastern tiger salamander
Plethodontidae	
Plethodon cinereus cinereus (Green)	Eastern red-backed salamander
P. glutinosus glutinosus (Green)	Slimy salamander
Hemidactylium scutatum (Schlegel)	Eastern four-toed salamander
E. longicauda longicauda (Green)	Long-tailed salamander
Eurycea lucifuga (Rafinesque)	Cave salamander
E. l. melanopleura (Cope)	Cope's Cave Salamander
Typhlotriton spelaeus Stejneger	Grotto salamander
Sirenidae	
Siren intermedia nettingi (Goin)	Western lesser siren
SALIENTIA - Frogs and Toads	
Ranidae	
Hyla versicolor versicolor (Le Conte)	Gray tree frog
H. crucifer crucifer (Wied)	Spring peeper
Pseudacris triseriata triseriata (Wied)	Western chorus frog
Acris crepitans	Cricket frog
Rana pipiens	Leopard frog
R. palustris (Le Conte)	Pickerel frog
R. areolata circulosa (Davis)	Northern gopher frog
R. sylvatica (Le Conte)	Wood frog
R. catesbeiana (Shaw)	Bullfrog
R. clamitans clamitans (Latreille)	Green frog
R. c. melanota (Rafinesque)	Bronze frog
Bufonidae	
Bufo americanus americanus (Holbrook)	American toad
B. a. charlesmithi (Bragg)	Dwarf American toad
B. woodhowsei fowleri (Hinkley)	Fowler's toad
Microhylidae	
Gastrophryne carolinensis (Holbrook)	Eastern narrow-mouthed toad

Source: (022, 023)

TABLE A5
REPTILES OF THE LOWER MERAMEC RIVER BASIN

TESTUDINES - Turtles

Chelydridae

Chelydra serpentina serpentina (Linnaeus)	Common snapping turtle
Macrochelys temmincki (Troost)	Alligator snapping turtle

Kinosternidae

Sternotharus odoratus (Latreille)	Stinkpot

Testudinidae

Terrapene carolina triunquis (Agassiz)	Three-toed box turtle
Terrapene ornata ornata (Agassiz)	Ornate box turtle
Chrysemys picta belli (Gray)	Western painted turtle
Pseudemys scripta elegans (Wied)	Red-eared turtle
Graptemys geographica (LeSueur)	Map turtle
Graptemys kohni (Baur)	Mississippi map turtle
Graptemys pseudogeographica ouachitensis Cagle	Ouachita map turtle

Trionychidae

Trionyx muticus muticus Le Sueur	Smooth softsheel turtle
Trionyx spinifer hartwegi (Conant & Goin)	Western spiny soft-shelled turtle

SQUAMATA: SAURIA - Lizards

Iguanidae

Crotaphytus collaris collaris (Say)	Eastern collared lizard
Sceloporus undulatus hyacinthinus (Green)	Northern fence lizard

Anguidae

Ophisaurus attenuatus attenuatus Cope (Baird)	Western slender glass lizard: Glass "snake"

Teiidae

Cnemidophorus sexlineatus (Linnaeus)	Six-lined racerunner

Scincidae

Scincella laterale (Say)	Ground skink
Eumeces fasciatus (Linnaeus)	Five-lined skink
Eumeces laticeps (Schneider)	Broad-headed skink
Eumeces anthracinus pluvialis Cope	Southern coal skink

SQUAMATA: SERPENTES - Snakes

Colubridae

Carphophis amoenus vermis (Kennicott)	Western worm snake
Diadophis punctatus arnyi (Kennicott)	Prairie ringneck snake
Heterodon platyrhinos Latreille	Eastern hognose snake
Opheodrys aestivus (Linnaeus)	Rough green snake
Coluber constrictor flaviventris Say	Eastern yellow-bellied racer
Masticophis flagellum flagellum (Shaw)	Eastern coachwhip
Elaphe guttata emoryi (Baird and Girard)	Great Plains rat snake
Elaphe obsoleta obsoleta (Say)	Black rat snake
Pituophis melanoleucus sayi (Schlegel)	Bullsnake
Lampropeltis calligaster calligaster (Harlan)	Prairie king snake
Lampropeltis getulus holbrooki Stejneger	Speckled king snake
L. triangulum syspila (Cope) [*L. doliata* (Linnaeus) (Anderson)]	Milk snake
Tantilla gracilus hallowelli Cope	Northern flat-headed snake
Thamnophis sauritus proximus (Say)	Western ribbon snake
Thamnophis sirtalis sirtalis (Linnaeus)	Eastern garter snake

TABLE A5

REPTILES OF THE LOWER MERAMEC RIVER BASIN
(continued)

Tropidoclonion lineatum lineatum (Hallowell)	Northern lined snake
Virginia valeriae elegans Kennicott	Western earth snake
Virginia striatula (Linnaeus)	Rough earth snake
Storeria dekayi wrightorum X *texana* (Trapido)	Midland brown snake or Texas brown snake
Storeria occipitomaculata occipitomaculata (Storer)	Northern red-bellied snake
Natrix *grahami* (Baird and Girard)	Graham's water snake
Natrix rhombifera rhombifera (Hallowell)	Diamond-backed water snake
Natrix sipedon sipedon (Linnaeus)	Northern water snake
Crotalidae	
Agkistrodon contortrix mokeson (Daudin)	Northern copperhead
Crotalus horridus horridus Linneaus	Timber rattlesnake

Source: (023, 024)

TABLE A6

BIRDS OF THE LOWER MERAMEC RIVER BASIN

GAVIFORMES - loons	
Gaviidae	
Gavia immer	Common loon
PODICIPEDIFORMES - grebes	
Podicipedidae	
Podiceps grisegena	Red-necked grebe
Podiceps auritus	Horned grebe
Podiceps caspicus	Eared grebe
Aechmophorus occidentalis	Western grebe
Podilymbus podiceps	Pied-billed grebe
PELECANIFORMES - pelicans, cormorants	
Pelecanidae	
Pelecanus erythrorhynchos	White pelican
Phalacrocoracidae	
Phalacrocorax auritus	Double-crested cormorant
CICONIIFORMES - herons, egrets, bitterns, ibises	
Ardeidae	
Ardea herodias	Great blue heron
Butorides virescens	Green heron
Florida caerulea	Little blue heron
Bubulcus ibis	Cattle egret
Casmerodius albus	Common egret
Leucophoyx thula	Snowy egret
Nycticorax nycticorax	Black-crowned night heron
Nyctanassa violacea	Yellow-crowned night heron
Ixobrychus exilis	Least bittern
Botaurus lentiginosus	American bittern
Ciconiidae	
Mycteria americana	Wood ibis
Threskiornithidae	
Plegadis falcinellus	Glossy ibis
Eudocimus albus	White ibis
ANSERIFORMES - swans, geese, ducks	
Anatidae	
Olor columbianus	Whistling swan
Branta canadensis	Canada goose
Anser albifrons	White fronted goose
Chen hyperborea	Snow goose
Chen caerulescens	Blue goose
Anas platyrhynchos	Mallard
Anas rubripes	Black duck
Anas strepera	Gadwall
Anas acuta	Pintail
Anas carolinensis	Green-winged teal
Anas discors	Blue-winged teal
Anas cyanoptera	Cinnamon teal
Mareca americana	American widgeon
Spatula clypeata	Shoveler
Aix sponsa	Wood duck
Aythya americana	Redhead
Aythya collaris	Ring-necked duck
Aythya valisineria	Canvasback
Aythya marila	Greater scaup
Aythya affinis	Lesser scaup
Bucephala clangula	Common golden-eye
Bucephala albeola	Bufflehead
Clangula hyemalis	Oldsquaw
Melanitta deglandi	White-winged scoter
Oidemia nigra	Common scoter
Oxyura jamaicensis	Ruddy duck
Lophodytes cucullatus	Hooded merganser
Mergus merganser	Common merganser
Mergus serrator	Red-breasted merganser

TABLE A6

BIRDS OF THE LOWER MERAMEC RIVER BASIN
(continued)

FALCONIFORMES - vultures, hawks, osprey, eagles, falcons	
Cathartidae	
Cathartes aura	Turkey vulture
Coragyps atratus	Black vulture
Accipitridae	
Ictinia misisippiensis	Mississippi kite
Accipiter gentilis	Goshawk
Accipiter striatus	Sharp-shinned hawk
Accipiter cooperii	Cooper's hawk
Buteo jamaicensis	Red-tailed hawk
Buteo harlani	Harlan's hawk
Buteo lineatus	Red-shouldered hawk
Buteo platypterus	Broad-winged hawk
Buteo swainsoni	Swainson's hawk
Buteo lagopus	Rough-legged hawk
Aquila chrysaetos	Golden eagle
Haliaeetus leucocephalus	Bald eagle
Circus cyaneus	Marsh hawk
Pandionidae	
Pandion haliaetus	Osprey
Falconidae	
Falco mexicanus	Prairie falcon
Falco peregrinus	Peregrine falcon
Falco columbarius	Pigeon hawk
Falco sparverius	Sparrow hawk
GALLIFORMES - quail, pheasants, turkeys	
Phasianidae	
Colinus virginianus	Bobwhite
Phasianus colchicus	Ring-necked pheasant
Meleagrididae	
Meleagris gallopavo	Turkey
GRUIFORMES - cranes, rails, gallinules, coots	
Gruidae	
Crus canadensis	Sandhill crane
Rallidae	
Rallus elegans	King rail
Rallus limicola	Virginia rail
Porzana carolina	Sora
Coturnicops noveboracensis	Yellow rail
Porphyrula martinica	Purple gallinule
Gallinula chloropus	Common gallinule
Fulica americana	American coot
CHARADRIIFORMES - plovers, sandpipers, gulls, terns	
Charadriidae	
Charadrius semipalmatus	Semipalmated plover
Charadrius melodus	Piping plover
Charadrius vociferus	Killdeer
Pluvialis dominica	American golden plover
Squatarola squatarola	Black-bellied plover
Arenaria interpres	Ruddy turnstone
Scolopacidae	
Philohela minor	American woodcock
Capella gallinago	Common snipe
Bartramia longicauda	Upland plover
Actitis macularia	Spotted sandpiper
Tringa solitaria	Solitary sandpiper
Catoptrophorus semipalmatus	Willet
Totanus melanoleucus	Greater yellowlegs
Totanus flavipes	Lesser yellowlegs
Calidrus canutus	Knot
Erolia melanotos	Pectoral sandpiper
Erolia fuscicollis	White-rumped sandpiper

TABLE A6

BIRDS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Erolia bairdii	Baird's sandpiper
Erolia minutilla	Least sandpiper
Erolia alpina	Dunlin
Limnodromus griseus	Short-billed dowitcher
Limnodromus scolopaceus	Long-billed dowitcher
Micropalama himantopus	Stilt sandpiper
Ereunetes pusillus	Semipalmated sandpiper
Ereunetes mauri	Western sandpiper
Limosa fedoa	Marbled godwit
Crocethia alba	Sanderling
Limosa haemastica	Hudsonian godwit
Tryngites subruficollis	Buff-breasted sandpiper
Recurvirostridae	
Recurvirostra americana	American avocet
Himantopus mexicanus	Black-necked stilt
Phalaropodidae	
Steganopus tricolor	Wilson's phalarope
Lobipes lobatus	Northern phalarope
Laridae	
Larus hyperboreus	Glaucous gull
Larus glaucoides	Iceland gull
Larus argentatus	Herring gull
Larus delawarensis	Ring-billed gull
Larus pipixcan	Franklin's gull
Larus philadelphia	Bonaparte's gull
Rissa brevirostris	Black-legged kittiwake
Sterna forsteri	Forster's tern
Sterna hirundo	Common tern
Sterna albifrons	Least tern
Hydroprogne caspia	Caspian tern
Chlidonias niger	Black tern
COLUMBIFORMES - pigeons, doves	
Columbidae	
Columba livia	Rock dove
Zenaidura macroura	Mourning dove
CUCULIFORMES - cuckoos	
Cuculidae	
Coccyzus americanus	Yellow-billed cuckoo
Coccyzus erythropthalmus	Black-billed cuckoo
STRIGIFORMES - owls	
Tytonidae	
Tyto alba	Barn owl
Styrigidae	
Otus asio	Screech owl
Bubo virginianus	Great horned owl
Nyctea scandiaca	Snowy owl
Strix varia	Barred owl
Asio otus	Long-eared owl
Asio flammeus	Short-eared owl
Aegolius acadicus	Saw-whet owl
CAPRIMULGIFORMES - goatsuckers	
Caprimulgidae	
Caprimulgus carolinensis	Chuck-will's-widow
Caprimulgus vociferous	Whip-poor-will
Chordeiles minor	Common nighthawk
APODIFORMES - swifts, hummingbirds	
Apodidae	
Chaetura pelagica	Chimney swift
Trochilidae	
Archilochus colubris	Ruby-throated hummingbird

TABLE A6

BIRDS OF THE LOWER MERAMEC RIVER BASIN
(continued)

CORACIIFORMES - kingfishers	
Alcedinidae	
Megaceryle alcyon	Belted kingfisher
PICIFORMES - woodpeckers	
Picidae	
Colaptes auratus	Yellow-shafted flicker
Colaptes cafer	Red-shafted flicker
Dryocopus pileatus	Pileated woodpecker
Centurus carolinus	Red-bellied woodpecker
Melanerpes erythrocephalus	Red-headed woodpecker
Sphyrapicus varius	Yellow-bellied sapsucker
Dendrocopos villosus	Hairy woodpecker
Dendrocopos pubescens	Downy woodpecker
PASSERIFORMES - perching birds	
Tyrannidae - flycatchers	
Tyrannus tyrannus	Eastern kingbird
Muscivora forficata	Scissor-tailed flycatcher
Myiarchus crinitus	Great crested flycatcher
Sayornis phoebe	Eastern phoebe
Empidonax flaviventris	Yellow-bellied flycatcher
Empidonax virescens	Acadian flycatcher
Empidonax traillii	Traill's flycatcher
Empidonax minimus	Least flycatcher
Contopus virens	Eastern wood pewee
Nuttallornis borealis	Olive-sided flycatcher
Alaudidae - larks	
Eremophila alpestris	Horned lark
Hirudinidae - swallows	
Iridoprocne bicolor	Tree swallow
Riparia riparia	Bank swallow
Stelgidopteryx ruficollis	Rough-winged swallow
Hirundo rustica	Barn swallow
Petrochelidon pyrrhonota	Cliff swallow
Progne subis	Purple martin
Corvidae - jays, crows	
Cyanocitta cristata	Blue jay
Corvus brachyrhynchos	Common crow
Corvus ossifragus	Fish crow
Paridae - chickadees, titmouse	
Parus atricapillus	Black-capped chickadee
Parus carolinensis	Carolina chickadee
Parus bicolor	Tufted titmouse
Sittidae - nuthatches	
Sitta carolinensis	White-breasted nuthatch
Sitta canadensis	Red-breasted nuthatch
Certhiidae - creepers	
Certhis familiaris	Brown creeper
Troglodytidae	
Troglodytes aedon	House wren
Troglodytes troglodytes	Winter wren
Thryomanes bewickii	Bewick's wren
Thryomanes ludovicianus	Carolina wren
Telmatodytes palustris	Long-billed marsh wren
Cistothorus platensis	Short-billed marsh wren
Mimidae - mimics	
Mimus polyglottos	Mockingbird
Dumetella carolinensis	Catbird
Toxostoma rufum	Brown thrasher
Turdidae - thrushes	
Turdus migratorius	Robin
Hylocichla mustelina	Wood thrush
Hylocichla guttata	Hermit thrush
Hylocichla ustulata	Swainson's thrush
Hylocichla minima	Gray-cheeked thrush
Hylocichla fuscescens	Veery
Sialia sialis	Eastern bluebird

TABLE A6

BIRDS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Sylviidae - gnatcatchers, kinglets	
Polioptila caerulea	Blue-gray gnatcatcher
Regulus satrapa	Golden-crowned kinglet
Regulus calendula	Ruby-crowned kinglet
Motacillidae - pipits	
Anthus spinoletta	Water pipit
Anthus spraguell	Sprague's pipit
Bombycillidae - waxwings	
Bombycilla garrulus	Bohemian waxwing
Bombycilla cedrorum	Cedar waxwing
Laniidae - shrikes	
Lanius ludovicianus	Loggerhead shrike
Sturnidae - starlings	
Sturnus vulgaris	Starling
Vireonidae - vireos	
Vireo griseus	White-eyed vireo
Vireo bellii	Bell's vireo
Vireo flavifrons	Yellow-throated vireo
Vireo solitarius	Solitary vireo
Vireo olivaceus	Red-eyed vireo
Vireo philadelphicus	Philadelphia vireo
Vireo gilvus	Warbling vireo
Parulidae - wood warblers	
Mniotilta varia	Black and white warbler
Protonotaria citrea	Prothonotary warbler
Helmitheros vermivorus	Worm-eating warbler
Vermivora chrysoptera	Golden-winged warbler
Vermivora pinus	Blue-winged warbler
Vermivora peregrina	Tennessee warbler
Vermivora celata	Orange-crowned warbler
Vermivora ruficapilla	Nashville warbler
Parula americana	Parula warbler
Dendroica petechia	Yellow warbler
Dendroica magnolia	Magnolia warbler
Dendroica tigrina	Cape May warbler
Dendroica caerulescens	Black-throated blue warbler
Dendroica coronata	Myrtle warbler
Dendroica virens	Black-throated green warbler
Dendroica cerulea	Cerulean warbler
Dendroica fusca	Blackburnian warbler
Dendroica dominica	Yellow-throated warbler
Dendroica pensylvanica	Chestnut-sided warbler
Dendroica castanea	Bay-breasted warbler
Dendroica striata	Blackpoll warbler
Dendroica pinus	Pine warbler
Dendroica discolor	Prairie warbler
Dendroica palmarum	Palm warbler
Seiurus aurocapillus	Ovenbird
Seiurus noveboracensis	Northern waterthrush
Seiurus motacilla	Louisiana waterthrush
Oporornis formosus	Kentucky warbler
Oporornis agilis	Connecticut warbler
Oporornis philadelphia	Mourning warbler
Geothlypis trichas	Yellowthroat
Icteria virens	Yellow-breasted chat
Wilsonia citrina	Hooded warbler
Wilsonia pusilla	Wilson's warbler
Wilsonia canadensis	Canada warbler
Setophaga ruticilla	American redstart
Ploceidae - weaver finches	
Passer domesticus	House sparrow
Passer montanus	European tree sparrow
Icteridae - meadowlarks, blackbirds, orioles	
Dolichonyx oryzivorus	Bobolink
Sturnella magna	Eastern meadowlark
Sturnella neglecta	Western meadowlark
Xanthocephalus xanthocephalus	Yellow-winged blackbird
Agelaius phoeniceus	Red-winged blackbird
Icterus spurius	Orchard oriole
Icterus galbula	Baltimore oriole
Euphagus carolinus	Rusty blackbird

TABLE A6

BIRDS OF THE LOWER MERAMEC RIVER BASIN
(continued)

Euphagus cyanocephalus	Brewer's blackbird
Quiscalus quiscula	Common grackle
Molothrus ater	Brown-headed cowbird
Thraupidae - tanagers	
Piranga ludoviciana	Western tanager
Piranga olivacea	Scarlet tanager
Piranga rubra	Summer tanager
Fringillidae - finches	
Cardinalis cardinalis	Cardinal
Pheucticus ludovicianus	Rose-breasted grosbeak
Guiraca caerulea	Blue grosbeak
Passerina cyanea	Indigo bunting
Spiza americana	Dickcissel
Hesperiphona vespertina	Evening grosbeak
Carpodacus purpureus	Purple finch
Pinicola enucleator	Pine grosbeak
Acanthis flammea	Common redpoll
Spinus pinus	Pine siskin
Spinus tristis	American goldfinch
Loxia curvirostra	Red crossbill
Loxia leucoptera	White-winged crossbill
Pipilo erythrophthalmus	Rufous-sided towhee
Passerculus sandwichensis	Savannah sparrow
Ammodramus savannarum	Grasshopper sparrow
Ammodramus bairdii	Baird's sparrow
Passerherbulus caudacutus	LeConte's sparrow
Passerherbulus henslowii	Henslow's sparrow
Ammospiza caudacuta	Sharp-tailed sparrow
Pooecetes gramineus	Vesper sparrow
Chondestes grammacus	Lark sparrow
Aimophila aestivalis	Bachman's sparrow
Junco hyemalis	Slate-colored junco
Junco oreganus	Oregon junco
Spizella arborea	Tree sparrow
Spizella passerina	Chipping sparrow
Spizella pallida	Clay-colored sparrow
Spizella pusilla	Field sparrow
Zonotrichia querula	Harris' sparrow
Zonotrichia albicollis	White-throated sparrow
Zonotrichia leucophrys	White-crowned sparrow
Passerella iliaca	Fox sparrow
Melospiza lincolnii	Lincoln's sparrow
Melospiza georgiana	Swamp sparrow
Melospiza melodia	Song sparrow
Calcarius lapponicus	Lapland longspur
Calcarius pictus	Smith's longspur
Plectrophenax nivalis	Snow bunting

Source: (001)

TABLE A7

RARE AND ENDANGERED MAMMALS OF THE LOWER MERAMEC RIVER BASIN

Scientific Name	Common Name	Comments	Status(a)
Myotis sodalis	Indiana bat	Widely distributed in Missouri during the summer breeding season; hibernation in caves in winter.	Endangered (M,F)
Myotis leibii	Small-footed myotis	Only one record of occurrence in Iron County; however, believed to occur in limited numbers elsewhere in Missouri in caves, rock crevices, in or near forested areas.	Endangered (M)
Myotis grisescens	Gray bat	Closely associated with limestone cave region of central and southern Missouri, limited distribution elsewhere as cave populations.	Endangered (M)
Myotis keenii	Keen's bat	Widely distributed in limited numbers in all regions of Missouri, probably more frequently in southern portions of the state.	Rare (M)
Plecotus townsendii	Western big-eared bat	Primarily occurs in southwestern and southern part of Missouri; utilizes caves in winter.	Endangered (M)
Plecotus rafinesquii	Eastern big-eared bat	Believed to occur in limited numbers in southeastern Missouri.	Endangered (M)
Canis niger(b)	Red wolf	Lack of knowledge about exact range; may occur in the Ozark Highlands, but positive evidence of existence in Missouri is lacking.	Possibly Extirpated (M) Endangered (F)
Ursus americanus(b)	Black bear	Occasional reports of occurrence south of the Missouri River; questionable occurrence in study area.	Endangered (M)
Mustela frenata	Long-tailed weasel	Rare in Missouri, most common in south-central and south-western portions.	Rare (M)
Lutra canadensis	River otter	Formerly occurred in all major watersheds of Missouri; occasionally reported along Missouri River and its major tributaries.	Endangered (M)

NOTES: (a)M = Missouri Rare and Endangered Species List, 1974
F = Federal Endangered Fauna List, 1974.
(b)Questionable occurrence in study area.

Source: (026, 021, 011)

TABLE A8

RARE AND ENDANGERED HERPTILES OF THE LOWER MERAMEC RIVER BASIN

Scientific Name	Common Name	Comments	Status[a]
Hemidactylium scutatum	Four-toed salamander	Only small relict populations of this terrestrial amphibian found in eastern and southeastern Missouri; may occur in Lower Meramec River Basin.	Rare (M)
Rana sylvatica	Wood frog	Small relict populations in southwest Missouri; may also occur in east-central Missouri; perhaps extirpated.	Endangered (M)
Macroclemys temminckii	Alligator snapping turtle	Primarily confined to states bordering the Gulf Coast and the Mississippi River; found in Missouri in turbid streams in the southeast lowland; distribution includes St. Louis and Jefferson Counties.	Rare (M)

NOTES: [a] M = Missouri Rare and Endangered Species List, 1974.

Source: (011, 023, 024, 026)

TABLE A9

RARE AND ENDANGERED BIRD SPECIES WHICH MAY OCCUR IN THE MERAMEC RIVER BASIN STUDY AREA

Scientific Name	Common Name	Comments	Status[a]
Phalacrocorax auritus	Double-crested cormorant	Believed to nest on islands in the Mississippi River north of St. Louis.	Endangered (M)
Coragys atratus	Black vulture	Missouri is northern limit of distribution; found primarily in southeastern lowlands.	Rare (M)
Ictinia misisippiensis	Mississippi kite	Nests primarily in the southeastern lowlands; known to occur along the Mississippi River north to St. Louis.	Rare (M)
Accipiter striatus	Sharp-shinned hawk	Range includes most of U.S., but more frequently encountered in the north than south; seen in Missouri as migrator rather than breeder.	Endangered (M)
Accipiter cooperii	Cooper's hawk	Similar to the sharp-shinned hawk, but observed less frequently.	Endangered (M)
Buteo lineatus	Red-shouldered hawk	Formerly very common in Missouri; now generally restricted to southern and southeastern portions of state.	Rare (M)
Haliaeetus leucocephalus alascensis	Northern bald eagle	Winters in Missouri in fair numbers.	Rare (M)
Pandion haliaetus	Osprey	No recent records of nesting, but may be observed infrequently during migration.	Endangered (M)
Falco peregrinus	Peregrine falcon	Formerly nested in Missouri, but now seen only infrequently during migration.	Endangered (M, F)
Rallus elegans	King rail	Formerly distributed state-wide in Missouri; however, becoming rare due to destruction of marsh habitat.	Rare (M)
Laterallus jamaicens	Black rail	May nest in Missouri, but very secretive; probably a vagrant (after 1940).	Undetermined (M)
Bartramia longicauda	Upland plover	Suffered from widespread destruction of prairie habitat.	Endangered (M)
Sterna albifrons	Least tern	Primarily a coastal species; nests on sandbars and mud flats, mainly along the Missouri River.	Rare (M)
Tyto alba	Barn owl	A permanent resident throughout the state, but uncommon.	Rare (M)
Aimophila aestivalis	Bachman's sparrow	Found in old field successional stage in eastern and southern U.S.; Missouri is on the northwestern margin of its range; nests in open fields south and southwest of St. Louis.	Endangered (M)

TABLE A9

RARE AND ENDANGERED BIRD SPECIES WHICH MAY OCCUR IN THE MERAMEC RIVER BASIN STUDY AREA
(continued)

Scientific Name	Common Name	Comments	Status[a]
Corvus ossifragus	Fish crow	Locally common along the Mississippi River north to southeast Missouri; this species' northernmost extension.	Rare (M)
Limnothlypis swainsonii	Swainson's warbler	Two reports in the St. Louis area, 1950 and 1962; accidental occurrence; a vagrant.	Rare (M)
Xanthocephalus xanthocephalus	Yellow-headed blackbird	Most records for St. Louis area in March or April; breeds only in northwestern corner of Missouri.	Rare (M)

NOTES: [a] M = Missouri Rare and Endangered Species List, 1974.
F = Federal Rare and Endangered Species List, 1974.

Source: (001, 008, 011, 024)

TABLE A10

RARE AND ENDANGERED FLORA OF THE LOWER MERAMEC RIVER BASIN

Scientific Name	Common Name	Habitat	County of Reported Occurrence in Study Area	Status(a)
Lycopodiaceae - clubmoss *Lycopodium lucidulum*	Shining clubmoss	Shaded crevices and ledges of sandstone bluffs	St. Louis Jefferson	Rare (M)
Ophioglossaceae - adder's tongue *Botrychium dissectum* var. *dissectum*	Cut-leaved grape fern	Rich wooded ravines and narrow wooded valleys	St. Louis	Rare (M)
Polypodiaceae - fern *Dryopteris austrica* var. *spinulosa*	Spinulose shield fern	Shaded crevices of moist sandstone bluffs	Jefferson	Rare (M)
Pinaceae - pine *Pinus virginiana*(b)	Scrub pine	Cultivated sections of estates	St. Louis	Rare (M)
Cupressaceae - cypress *Juniperus virginiana* var. crebra	Red cedar	Limestone bluffs	Jefferson	Rare (M)
Alismaceae - water plantain *Echinodorus tenellus* var. *parvulus*		Originally collected along margins of ponds which have since been destroyed	St. Louis - probably extirpated; last collection date - 1845	Rare (M)
Gramineae - grasses *Distichlis stricta*	Inland salt grass	Waste areas and along railroads	St. Louis	Rare (M)
Aira elegans(b)	Hairgrass	Dry, sterile soil along roadsides and waste areas	St. Louis	Rare (M)
Heleochloa schoenoides(b)		Fields, meadows, along railroads and waste places	St. Louis	Rare (M)
Arthraxon hispidus var. *hispidus*(b)		Collected growing about the margins of a lagoon	St. Louis	Rare (M)

TABLE A10

RARE AND ENDANGERED FLORA OF THE LOWER MERAMEC RIVER BASIN (continued)

Scientific Name	Common Name	Habitat	County of Reported Occurence in Study Area	Status(a)
Cynosurus echinatus(b)		Along railroads	St. Louis	Rare (M)
Paspalum urvillei		Along railroads	St. Louis	Rare (M)
Pennisetum ciliare		Along railroads	St. Louis	Rare (M)
Cyperaceae-sedges				
Scirpus olneyi	Olney's bulrush	Sulphur springs	Jefferson	Undetermined (M)
Carex douglasii	Douglas' sedge	Along railroads	St. Louis	Endangered (M)
Carex gracillima	Graceful sedge	In low woods along streams	St. Louis	Undetermined (M)
Carex nebraskensis		Along railroads	St. Louis	Rare (M)
Carex schweinitzii	Schweinitz's sedge	Railroad yards, low areas	St. Louis	Endangered (M)
Araceae-Arum				
Peltandra virginica	Arrow arum	Wet, mucky ground bordering sloughs, and oxbow lakes of river bottoms	St. Louis Jefferson	Rare (M)
Orchidaceae-orchid				
Cypripedium candidum	Small white lady-slipper	Low wooded slopes bordering streams and valleys; wet prairies	St. Louis - probably extirpated; last collection date - 1838	Rare (M,F)
Habenaria leucophaea	Prairie white fringed orchid	Low, moist river bottom prairies and spring-fed, calcareous meadows along small valleys	St. Louis Jefferson	Rare (F)
Spiranthes ovalis		Low, or rich, moist woodland	St. Louis	Rare (M)
Malaxis unifolia f. unifolia	Green adder's mouth	Dry, rich woodland and valley floors bordering streams	St. Louis Jefferson	Rare (M)
Ulmaceae-elm				
Ulmus Spp.	Elm	Various habitats throughout state	St. Louis Jefferson	Endangered (M), due to Dutch Elm Disease

TABLE A10

RARE AND ENDANGERED FLORA OF THE OWER MERAMEC RIVER BASIN
(continued)

Scientific Name	Common Name	Habitat	County of Reported Occurence in Study Area	Status(a)
Polygonaceae-buckwheat				
Rumex patientia(b)	Patience dock	Waste ground and along railroads	St. Louis	Rare (M)
Rumex orbiculatus (b)	Water dock	Moist alluvial ground	St. Louis	Rare (M)
Rumex pulcher(b)	Fiddle dock	Along railroads	St. Louis	Rare (M)
Rumex conglomeratus (b)		Waste places	St. Louis	Rare (M)
Polygonum bicorne	Knotweed, smartweed	Swampy or low wet ground near streams and along railroads	St. Louis	Rare (M)
Polygonum cespitosum var. longisetum(b)		Waste ground, lawns, along roadsides	St. Louis	Rare (M)
Chenopodiaceae-goosefoot				
Chenopodium glaucum var. salinum(b)		Along railroads, freight yards	St. Louis	Rare (M)
Chenopodium urbicum(b)	City goosefoot	Waste ground, dumps, and about dwellings	St. Louis	Rare (M)
Atriplex rosea(b)	Red scale	On soils bordering saline or sulfur springs; waste ground and along railroads	St. Louis	Rare (M)
Attriplex argentea	Silver scale	Waste ground and along railroads	St. Louis	Rare (M)
Monolepis nuttalliana(b)	Poverty weed	Waste ground and along railroads	St. Louis	Rare (M)
Amaranthaceae-Amaranth				
Amaranthus palmeri(b)		Waste ground and along railroads	St. Louis	Rare (M)
Amaranthus torreyi(b)		Waste ground and along railroads	St. Louis	Rare (M)
Amaranthus powellii(b)		Waste ground and along railroads	St. Louis	Rare (M)
Nyctaginaceae - four o'clock				
Boerhaavia erecta(b)		Along railroads	St. Louis	Rare (M)
Caryophyllaceae - pink				
Silene conoidea(b)		Along railroads	St. Louis	Rare (M)
Silene dichotoma(b)	Forking catchfly	Along railroads	St. Louis	Rare (M)
Silene cserei(b)		Waste ground and along railroads	St. Louis	Rare (M)
Silene cucubalus var. cucubalus(b)	Bladder campion	Fields, waste ground, and along railroads	St. Louis	Rare (M)
Silene noctiflora(b)	Night-flowering catchfly	Waste and cultivated ground; along railroads and roadsides	St. Louis	Rare (M)

TABLE A10

RARE AND ENDANGERED FLORA OF THE LOWER MERAMEC RIVER BASIN (continued)

Scientific Name	Common Name	Habitat	County of Reported Occurrence in Study Area	Status(a)
Ranunculaceae-crowfoot				
Ranunculus acris var. acris(b)	Tall buttercup	Along railroads	St. Louis	Rare (M)
Ranunculus sardous(b)		Moist, low ground of fields, meadows; along ditches and wet depressions	St. Louis	Rare (M)
Ranunculus arvensis(b)		Along railroads	St. Louis	Rare (M)
Adonis aestivalis var. citrina(b)	Summer adonis	Cultivated fields and open ground	St. Louis	Rare (M)
Clematis dioscoreifolia var. dioscoreifolia(b)	Virgin's bower	Along railroads, roadsides and waste areas	St. Louis	Rare (M)
Papaveraceae-poppy				
Argemone mexicana(b)	Prickly poppy	Rocky or open ground and along railroads	St. Louis	Rare (M)
Eschscholtzia californica(b)	California poppy	Along railroads	St. Louis	Rare (M)
Cruciferae-mustard				
Brassica napus var. napobrassica(b)	Rutabaga	Along railroads	St. Louis	Rare (M)
Erucostrum gallicum(b)		Waste ground and along railroads	St. Louis	Rare (M)
Raphanus raphanistrum(b)	Wild radish	Along railroads	St. Louis	Rare (M)
Cardaria pubescens var. elongata(b)	White top	Along railroads	St. Louis	Rare (M)
Neslia paniculata(b)	Ball mustard	Along railroads	St. Louis	Rare (M)
Berteroa incana(b)	Hoary alyssum	Along railroads and waste ground	St. Louis	Rare (M)
Chorispora tenella(b)		Along railroads	St. Louis	Rare (M)
Sisymbrium loeselii(b)		Along railroads	St. Louis	Rare (M)
Camelina sativa(b)	False flax	Along railroads and waste ground	St. Louis	Rare (M)
Capparidaceae-caper				
Cleome serrulata(b)	Rocky Mountain bee plant	Along railroads and waste ground	St. Louis	Rare (M)
Geraniaceae-Geranium				
Geranium dissectum(b)	Cranesbill	Lawns and grassy open ground	St. Louis	Rare (M)
Geranium molle(b)	Dovesfoot cranesbill	Lawns and grassy open ground	St. Louis	Rare (M)

TABLE A10

RARE AND ENDANGERED FLORA OF THE LOWER MERAMEC RIVER BASIN
(continued)

Scientific Name	Common Name	Habitat	County of Reported Occurrence in Study Area	Status(a)
Erodium texanum(b)		Along railroads	St. Louis	Rare (M)
Rutaceae-rue				
Ruta graveolens(b)	Common rue	Gardens, rarely escaping to waste grounds	St. Louis	Rare (M)
Malvaceae-mallow				
Callirhoe triangulata	Clustered poppy mallow	Rocky open woods, sandy open ground, sandy prairies and glades, generally in acidic soils	St. Louis	Rare (M)
Ongraceae-evening primrose				
Oenothera kunthiana(b)		Along railroads	St. Louis	Rare (M)
Unbelliferae-parsley				
Anthriscus scandicina(b)	Chervil	Along railroads	St. Louis	Rare (M)
Torilis nodosa(b)		Along railroads	St. Louis	Rare (M)
Bupleurum rotundifolium(b)	Thoroughwax	Fields, waste ground, along railroads	Jefferson	Rare (M)
Ammi majus(b)		Along railroads	St. Louis	Rare (M)
Cynosciadium pinnatum		Wet depressions and borders of shallow pools in rocky glades, and locally introduced along railroads	St. Louis	Rare (M)
Asclepiadaceae-milkweed				
Asclepias meadii	Milkweed	Prairies and glades	St. Louis	Rare (F)
Matelea obliqua	Climbing milkweed	Rocky woods and thickets	St. Louis	Rare (M)
Convolvulaceae-morning glory				
Evolvulus alsinoides(b)		Accidentally introduced	St. Louis	Rare (M)
Ipomoea cairica(b)		Along railroads	St. Louis	Rare (M)
Cuscuta indecora var. neuropetala(b)		Along railroads on various herbaceous plants		
Boraginaceae-borage				
Symphytum officinale(b)	Common comfrey	Along roadsides and waste ground	Jefferson	Rare (M)
Lithospermum latifolium	Puccoon, gromwell	Rich woods, on slopes, level valleys of alluvial soils near streams and in thickets	St. Louis	Rare (M)

TABLE A10

RARE AND ENDANGERED FLORA OF THE LOWER MERAMEC RIVER BASIN (continued)

Scientific Name	Common Name	Habitat	County of Reported Occurrence in Study Area	Status(a)
Amsinckia lycopsoides(b)		Along railroads	St. Louis	Rare (M)
Labiatae-mint				
Glechoma hederacea var. hederacea(b)	Ground ivy	Low woodlands, in valleys and banks along streams, wasteground, along roadsides and railroads	St. Louis	Rare (M)
Dracocephalum parviflorum(b)	Dragonhead	Waste grounds and along railroads	St. Louis	Rare (M)
Stachys hyssopifolia var. ambigua	Hedge nettle	Low moist ground and open grassy areas	St. Louis	Undetermined (M)
Solanaceae-nightshade				
Solanum villosum(b)		Waste ground along railroads	St. Louis	Rare (M)
Scrophulariaceae-figwort				
Cymbalaria muralis(b)	Kenilworth ivy	Waste ground and along roadsides	St. Louis	Rare (M)
Plantaginaceae-plantain				
Plantago wrightiana(b)		Along railroads	St. Louis	Rare (M)
Orobanchaceae - broom-rape				
Orobanche ludoviciana	Broom-rape	Parasitic on other plants	St. Louis	Endangered (M)
Cucurbitaceae-gourd				
Lagenaria siceraria(b)	Bottle gourd	Along railroads	St. Louis	Rare (M)
Compositae-composita				
Eupatorium capillifolium(b)		Along railroads	St. Louis	Rare (M)
Gutierrezia texana(b)		Along railroads	St. Louis	Rare (M)
Boltonia asteroides var. decurrens		Alluvial ground bordering sloughs, ditches, ponds and streams	St. Louis	Rare (F)
Aster commutatus	White prairie aster	Fields and along railroads	St. Louis	Rare (M)
Franseria discolor(b)		Along railroads	St. Louis	Undetermined (M)
Xanthium spinosum var. spinosum	Spiny cocklebur	Waste areas, fields, and along railroads	St. Louis	Undetermined (M)
Ratibida tagetes(b)		Along railroads	St. Louis	Rare (M)
Thelesperma ambiguum(b)		Along railroads	St. Louis	Rare (M)
Coreopsis cardaminefolia(b)		Along railroads	St. Louis	Rare (M)

TABLE A10

RARE AND ENDANGERED FLORA OF THE LOWER MERAMEC RIVER BASIN
(continued)

Scientific Name	Common Name	Habitat	County of Reported Occurence in Study Area	Status (a)
Cosmos bipinnatus (b)	Cosmos	Escaped from cultivation in waste ground and along railroads	St. Louis	Undetermined (M)
Matricaria maritima var. agrestis		Waste areas	St. Louis	Undetermined (M)
Artemisia vulgaris var. vulgaris (b)	Common mugwort	Along railroads	St. Louis	Undetermined (M)
Artemisia vulgaris var. glabra (b)		Along railroads	St. Louis	Undetermined (M)
Artemisia vulgaris var. latiloba (b)		Along railroads	St. Louis	Undetermined (M)
Senecio vulgaris (b)	Common groundsel	Along railroads and waste ground	St. Louis	Undetermined (M)
Senecio ampullaceus (b)		Along railroads	St. Louis	Rare (M)
Carduus crispus (b)	Curly thistle	Waste ground and along roadsides	St. Louis	Undetermined (M)
Centaurea diffusa (b)		Along railroads	St. Louis	Rare (M)
Centaurea nigra var. nigra (b)	Knapweed	Along railroads	St. Louis	Undetermined (M)
Picris sprengeriana (b)	Bitter-weed	Along railroads	St. Louis	Undetermined (M)
Tragopogon pratensis (b)	Goat's beard	Along railroads and waste grounds	St. Louis	Undetermined (M)
Sonchus arvensis var. glabrescens	Field sow thistle	Waste ground and roadsides	St. Louis	Undetermined (M)
Crepis pulchra (b)	Hawk's beard	Along railroads	St. Louis	Undetermined (M)
Crepis tectorum (b)		Along railroads	St. Louis	Rare (M)
Prenanthes racemosa		Wet prairies and low ground bordering streams	St. Louis St. Lou	Endangered (M)

NOTES: (a) M = Missouri Rare and Endangered Species List, 1974
F = Federal Endangered and Threatened Species List, 1975
(b) Species which have been introduced and naturalized

Source: (014,011,025)

TABLE A11
ALGAE COLLECTED IN THE LOWER MERAMEC RIVER(a)

	Station Numbers(b)(c)		
	M-11	M-12	M-13
Chlorophyta (green algae)			
Actinastrum	p	p	
Ankistrodesmus		p	
Apiocystis		p	
Cladophora	p	p p p	p
Closterium		p	
Cosmarium	p	p	p
Microspora	p	p	p
Stigeoclonium		p	
Ulothrix	p		
Cyanophyta (blue-green algae)			
Oscillatoria		p	
Chrysophyta (diatoms)			
Anomoeoneis			p
Asterionella		p p	p
Biddulphia			p
Bacillaria	p		
Cocconeis	p	p p p	p
Cyclotella	p		p
Cymbella	p	p p p	
Denticula		p	
Diatoma		p	
Frustulia			p
Gomphoenema	p	p p	p
Gyrosigma		p p p	p
Navicula	p	p p p	p
Rhopalodia		p	
Surirella		p p	
Synedra	p	p p	
Tabellaria		p p	

TABLE A11

ALGAE COLLECTED IN THE LOWER MERAMEC RIVER[a]

(continued)

NOTES: [a] All organisms identified to genera only

[b] p means present

[c] Location of letter in box designates season of collection as follows:

Fall	Winter
Spring	Summer

Source: (004)

TABLE A12

BENTHIC MACROINVERTEBRATES COLLECTED IN THE LOWER MERAMEC RIVER

	Station Numbers					
	M-11[a]		M-12[b]		M-13[c]	
Plecoptera (Stonefly nymphs)						
Brachyptera fasciata		100[d]		3		1
Taeniopteryx maura		30		1		
Taeniopteryx sp.		15		1		
Allocapnia sp.		4				2
Perlidae			2			
Neoperla clymene	7 16	3 2	2	1 4	1	2
Perlesta placida	3				1	
Acroneuria sp.					1	
Phasganophora capitata	5 4	2 2	3 2	4		
Hastaperla brevis	1					
Isoperla richardsoni	12		50		3	
Total	9		6		6	
Ephemeroptera (Mayfly naiads)						
Potamanthus sp.	2 2	1 3	8 2	2 5		
Hexagenia limbata					6	
Hexagenia rigida						1
Caenis sp.				10	9	8
Tricorythodes sp.	2 30	3 12	3 50	10 300	15 30	300
Ephemerella (bicolor gp.)					1	
Ephemerella needhami	10		15			
Baetisca bajkovi	1					
Baetinae	1		3		1	
Centroptilum sp.	10		2		8 1	8
Baetis sp.		70		40	1	6
Isonychia sp.	10	30 100	15	4	5	20
Pseudocloeon sp.	5	13	1 3		1	2

TABLE A12

BENTHIC MACROINVERTEBRATES COLLECTED IN THE LOWER MERAMEC RIVER
(continued)

	Station Numbers					
	M-11[a]		M-12[b]		M-13[c]	
Neocloeon alamance			3			
Stenonema (interpunctatum gp.)		2	3 10		6 15	2 2
Stenonema tripunctatum			1 2		1	
Stenonema (near pulchellum)	15	30	30	10		
Stenonema (near ares)	10	20		20 3	200 50	10 11
Stenonema sp.	4		40 30	5	10 40	
Heptagenia maculipennis						1
Heptagenia sp.			1		2	
Total	12		15		13	
Odonata (Damselfly nymphs)						
Gomphidae	1			1		
Erpetogomphus					1	
Argia	2		3 5	2 8	10 10	2 20
Hetaerina		1				
Total	3		2		2	
Trichoptera (Caddisfly larvae)						
Neureclipsis crepuscularis	1				4	
Cheumatopsyche sp.	8 12	10 90	2		42 20	10
Hydropsyche (near cuanis)	3	2 5			5	
Hydropsyche simulans		3				
Hydroptiliadae				2		
Agraylea sp.		10				12
Neotrichia sp.					20	2
Total	5		2		5	
Coleoptera (Beetles)						
Agabus sp.					1	
Berosus sp.	1	1				
Helichus sp.	1					

TABLE A12

BENTHIC MACROINVERTEBRATES COLLECTED IN THE LOWER MERAMEC RIVER (continued)

	Station Numbers					
	M-11[a]		M-12[b]		M-13[c]	
Elmidae			8			
Dubiraphia sp.					1	
	1		1		1	
Macronychus sp.						
			1			
Stenelmis sp.	100	10		3	17	
	30	80	50	200	20	50
Total	4		4		3	
Diptera (flies, mosquitoes, midges)						
Eriocera longicornis				2		
	1					
Simuliidae		2				
		60	20	20	1	
Tendipedidae	1	50	7	20	20	20
	10	70	100	150	50	40
Bezzia, Probezzia						
						1
Tabanus, Chrysops	2					
	1					
Atherix variegata	1	3				
		1				
Empididae						
				5		
Total	5		4		3	
Other Insecta						
Corydalus cornutus	3	1	16	6	2	
	3	40	4	25		
Sialis sp.		1			4	3
						4
Elophila sp.	1	2				
	1	1		1		
Total	3		2		2	
Gastropoda (snails)						
Goniobasis	20	20	1			
	50	20	1	3		
Pleurocera	5	2	3		80	5
	6	20		20	25	60
Ferrissia		3		5		10
			2	1	10	
Physa	1	d[e]			5	10
					5	
Lymnaea		1				
Amnicola						3
			1	d	100	
Somatogyrus					10	
Planorbidae						3
					5	
Total	5		4		7	

TABLE A12

BENTHIC MACROINVERTEBRATES COLLECTED IN THE LOWER MERAMEC RIVER (continued)

	Station Numbers					
	M-11(a)		M-12(b)		M-14(c)	
Crustacea						
Gammarus fasciatus					3	
Gammarus sp.					1	
Orconectes sp.			6 4		2	2
Total	0		1		2	
Miscellaneous Groups						
Turbellaria				1	6	5 3
Oligochaeta	4 1		1		15 2	6
Total	1		2		2	
Pelecypoda (mussels)						
Sphaeriidae						
Sphaerium sp.	1	1 2	50 40	10 50	60 100	25
Unionidae						
Unioninae						
Megalonaias gigantea						a(f)
Quadrula pustulosa						a
Lampsilinae						
Obliquaria reflexa						a
Actinonaias carinata				a		
Plagiola lineolata						
Truncilla truncata						a
Truncilla doniciformis						a
Leptodea fragilis						d
Proptera alata						a
Proptera laevissima						a
Lampsilis anodontoides						a
Lampsilis ovata						a
Total	4		2		10	

TABLE A12

BENTHIC MACROINVERTEBRATES COLLECTED IN THE LOWER MERAMEC RIVER
(continued)

NOTES:
(a) Station at Times Beach
(b) Station at Valley Park
(c) Station at Highway 67 Bridge
(d) Location of numbers in box designate season of collection as follows:

Fall	Winter
Spring	Summer

(e) "d" means specimen(s) dead
(f) "a" means specimen(s) alive

Source: (004)

TABLE A13
PELECYPOD MOLLUSCS OF THE LOWER MERAMEC RIVER

Species	Station(a) 3	Station(a) 4
Actinonaias carinata		
A. ellipsiformis		
A. ligamentina	x	x
Alasmidonta marginata	x	
Amblema plicata	x	x
A. p. f. costata		
Anodonta grandis	x	x
A. imbecilis		
Arcidens confragosus	x	x
Cumberlandia monodonta	x	
Cyclonaias tuberculata	x	
Dysnomia sp.		
D. triquetra		
Elliptio crassidens		
E. dilatatus	x	x
Fusconaia ebena		
F. flava f. flava	x	x
F. flava f. trigona	x	x
F. f. f. undata		
F. undata		
Lampsilis a. f. anodontoides		
L. a. f. fallaciosa	x	x
L. brevicula		
L. higginsi	x	x
L. ovata		
L. ovata f. ventricosa	x	x
L. radiata luteola		
L. siliquoidea		
Lasmigona complanata	x	x
L. compressa		
L. costata	x	x
Leptodea fragilis	x	x
L. leptodon		x
Ligumia recta	x	x
Megalonaias gigantea	x	x
Micromya sp.		
Obliquaria reflexa	x	x
Obovaria olivaria		
Pisidium sp.		
Plagiola lineolata	x	x
Pleurobema c. f. coccineum	x	x
P. c. f. catillus	x	x
P. cordatum		
Plethobasus cyphyus	x	x
Potamilus alata	x	x
P. laevissimus	x	x
Quadrula metanevra	x	x
Q. pustulosa	x	x
Q. quadrula	x	x
Sphaerium sp.		
Strophitus rugosus		
S. undulatus	x	x
Toxolasma parva	x	x
Tritogonia verrucosa	x	x
Truncilla donaciformis	x	x
T. truncata	x	x

NOTES: (a) See Figure for station locations.

Source: (001)

TABLE A14

FISHES OF THE LOWER MERAMEC RIVER BASIN

PETROMYZONTIFORMES	
Petromyzontidae	
Ichthyomyzon fossor Reighard and Cummins	Northern brook lamprey
Ichthyomyzon castaneus Girard	Chestnut lamprey
Lampetra aepyptera (Abbott)	Least Brook lamprey
ACIPENSERIFORMES	
Polyodontidae - paddlefishes	
Polyodon spathula (Walbaum)	Paddlefish
SEMIONOTIFORMES	
Lepisosteidae - gars	
Lepisosteus platostomus Rafinesque	Shortnose gar
Lepisosteus osseus (Linneaus)	Longnose gar
AMIIFORMES	
Amiidae - bowfins	
Amia calva Linnaeus	Bowfin
ANGUILLIFORMES	
Anguillidae - freshwater eels	
Anguilla rostrata (Lesueur)	American eel
CLUPEIFORMES	
Clupeidae - herrings	
Alosa chrysochloris (Rafinesque)	Skipjack herring
Alosa alabamae Jordan and Evermann	Alabama shad
Dorosoma cepedianum (Lesueur)	Gizzard shad
OSTEOGLOSSIFORMES	
Hiodontidae - mooneyes	
Hiodon alosoides (Rafinesque)	Goldeye
Hiodon tergisus Lesueur	Mooneye
SALMONIFORMES	
Salmonidae - trouts	
Salmo gairdneri Richardson	Rainbow trout
Esocidae - pikes	
Esox americanus vermiculatus Lesueur	Grass pickerel
CYPRINIFORMES	
Cyprinidae - minnows and carps	
Cyprinus carpio Linnaeus	Carp
Carassius auratus (Linnaeus)	Goldfish
Notemigonus crysoleucas (Mitchill)	Golden shiner
Semotilus atromaculatus (Mitchill)	Creek chub
Phoxinus erythrogaster (Rafinesque)	Southern redbelly dace
Nocomis biguttatus (Kirtland)	Hornyhead chub
Hybopsis storeriana (Kirtland)	Silver chub
Hybopsis amblops (Rafinesque)	Bigeye chub
Hybopsis x-punctata Hubbs and Crowe	Gravel chub
Phenacobius mirabilis (Girard)	Suckermouth minnow
Notropis atherinoides Rafinesque	Emerald shiner
Notropis rubellus (Agassiz)	Rosyface shiner
Notropis umbratilis (Girard)	Redfin shiner
Notropis zonatus (Putnam)	Bleeding shiner
Notropis chrysocephalus (Rafinesque)	Striped shiner
Notropis greenei Hubbs and Ortenburger	Wedgespot shiner
Notropis boops Gilbert	Bigeye shiner
Notropis dorsalis (Agassiz)	Bigmouth shiner
Notropis amnis Hubbs and Greene	Pallid shiner
Notropis whipplei (Girard)	Steelcolor shiner

TABLE A14

FISHES OF THE LOWER MERAMEC RIVER BASIN
(continued)

Notropis spilopterus (Cope)	Spotfin shiner
Notropis lutrensis (Baird and Girard)	Red shiner
Notropis stramineus (Cope)	Sand shiner
Notropis volucellus (Cope)	Mimic shiner
Notropis buchanani Meek	Ghost shiner
Dionda nubila (Forbes)	Ozark minnow
Ericymba buccata Cope	Silverjaw minnow
Pimephales vigilax (Baird and Girard)	Bullhead minnow
Pimephales notatus (Rafinesque)	Bluntnose minnow
Pimephales promelas Rafinesque	Fathead minnow
Campostoma anomalum (Rafinesque)	Stoneroller
Catostomidae - suckers	
Carpiodes carpio (Rafinesque)	River carpsucker
Carpiodes cyprinus (Lesueur)	Quillback
Carpiodes velifer (Rafinesque)	Highfin carpsucker
Catostomus commersoni (Lacepede)	White sucker
Hypentelium nigricans (Lesueur)	Northern hog sucker
Erimyzon sucetta (Lacepede)	Lake chubsucker
Erimyzon oblongus (Mitchell)	Creek chubsucker
Ictiobus cyprinellus (Valenciennes)	Bigmouth buffalo
Ictiobus niger (Rafinesque)	Black buffalo
Ictiobus bubalus (Rafinesque)	Smallmouth buffalo
Minytrema melanops (Rafinesque)	Spotted sucker
Cycleptus elongatus (Lesueur)	Blue sucker
Moxostoma duquesnei (Lesueur)	Black redhorse
Moxostoma erythrurum (Rafinesque)	Golden redhorse
Moxostoma anisurum (Rafinesque)	Silver redhorse
Moxostoma macrolepidotum (Lesueur)	Shorthead redhorse
Moxostoma carinatum (Cope)	River redhorse
SILURIFORMES	
Ictaluridae - freshwater catfishes	
Ictalurus melas (Rafinesque)	Black bullhead
Ictalurus natalis (Lesueur)	Yellow bullhead
Ictalurus punctatus (Rafinesque)	Channel catfish
Noturus exilis Nelson	Slender madtom
Noturus flavus Rafinesque	Stonecat
Noturus nocturnus (Jordan & Gilbert)	Freckled madtom
Pylodictis olivaris (Rafinesque)	Flathead catfish
ANTHERINIFORMES	
Cyprinodontidae - killifishes	
Fundulus catenatus (Storer)	Northern studfish
Fundulus olivaceus (Storer)	Blackspotted topminnow
Fundulus notatus (Rafinesque)	Blackstripe topminnow
Poeciliidae - livebearers	
Gambusia affinis (Baird and Girard)	Mosquitofish
Atherinidae - silversides	
Labidesthes sicculus (Cope)	Brook silverside
PERCIFORMES	
Percichthyidae - temperate basses	
Morone chrysops (Rafinesque)	White bass
Centrachidae - sunfishes	
Micropterus dolomieui Lacepede	Smallmouth bass
Micropterus salmoides (Lacepede)	Largemouth bass
Lepomis cyanellus Rafinesque	Green sunfish
Lepomis gibbosus (Linnaeus)	Pumpkinseed
Lepomis humilis (Girard)	Orangespotted sunfish
Lepomis megalotis (Rafinesque)	Longear sunfish
Lepomis macrochirus Rafinesque	Bluegill
Lepomis microlophus	Redear sunfish
Ambloplites rupestris (Rafinesque)	Rock bass
Pomoxis nigromaculatus (Lesueur)	Black crappie
Pomoxis annularis Rafinesque	White crappie
Lepomis gulosus (Cuvier)	Warmouth

TABLE A14

FISHES OF THE LOWER MERAMEC RIVER BASIN
(continued)

Percidae - perches	
Ammocrypta asprella (Jordon)	Crystal darter
Ammocrypta clara Jordan and Meek	Western sand darter
Etheostoma nigrum Rafinesque	Johnny darter
Etheostoma tetrazonum (Hubbs and Black)	Missouri saddled darter
Etheostoma zonale (Cope)	Banded darter
Etheostoma blennioides Rafinesque	Greenside darter
Etheostoma asprigene (Forbes)	Mud darter
Etheostoma caeruleum Storer	Rainbow darter
Etheostoma spectabile (Agassiz)	Orangethroat darter
Etheostoma flabellare Rafinesque	Fantail darter
Etheostoma microperca Jordan and Gilbert	Least darter
Percina phoxocephala (Nelson)	Slenderhead darter
Percina caprodes (Rafinesque)	Logperch
Percina evides (Jordan and Copeland)	Gilt darter
Percina shumardi (Girard)	River darter
Stizostedion vitreum (Mitchill)	Walleye
Stizostedion canadense (Smith)	Sauger
Sciaendidae - drums	
Aplodinotus grunniens Rafinesque	Freshwater drum
Cottidae - sculpins	
Cottus bairdi Girard	Mottled sculpin
Cottus carolinae (Gill)	Banded sculpin

Source: (009)

TABLE A15
MISSOURI ELECTRICITY RATES

SYLLABUS OF RESIDENCE RATE - SERVICE CLASSIFICATION NO. 1 (M)

Applying to All Service Areas in Missouri

Applying to electric service when used for all residential purposes in separately metered dwelling units.

1. NET RATE BASED ON MONTHLY METER READINGS

SUMMER RATE
(Applicable during 5 monthly billing periods of June through October.)

First 100 kwhr or less	$4.83 per month
Next 150 kwhr	@ 3.89¢ per kwhr
Over 250 kwhr	@ 3.47¢ per kwhr

WINTER RATE
(Applicable during 7 monthly billing periods of November through May.)

First 100 kwhr or less	$4.83 per month
Next 150 kwhr	@ 3.89¢ per kwhr
Next 350 kwhr	@ 3.47¢ per kwhr
Next 400 kwhr	@ 3.17¢ per kwhr
Over 1000 kwhr	@ 2.63¢ per kwhr

WATER HEATING CREDIT.

Applicable to the first 350 kwhr in excess of 250 kwhr per month during each monthly billing period 1.34¢ per kwhr.

SPACE HEATING ALLOWANCE.

When electric space heating of a type approved by Company has been installed as the sole source of heat for the entire premises, each kwhr over 1,000 kwhr per month will be charged 1.31 cents per kwhr during 7 monthly billing periods of November through May, in lieu of the above charge.

2. MINIMUM MONTHLY CHARGE

$4.83 per meter.

3. FUEL ADJUSTMENT

Applicable to all metered kwhr to compensate for changes in cost of fuel as set forth under Company's Rider "A".

4. TAX ADJUSTMENT

Any license, franchise, gross receipts, occupation or similar charge or tax levied by any taxing authority on the amounts billed will be so designated and added as a separate item to bills rendered to customers under the jurisdiction of the taxing authority.

5. SPECIAL APPLICATIONS.

Rate is applicable to residential service in apartment buildings where each single family dwelling unit is supplied through a separate main meter and to farm use and combination home and farm use not classified as commercial. Summer cottages and dwellings occupied for a period of less than one year are entitled to the rate with certain qualifications.

TABLE A15

MISSOURI ELECTRICITY RATES
(Continued)

6. ELIGIBILITY FOR WATER HEATING CREDIT.

30 gallon or larger fast recovery heater with one or two heating elements, suitable for 208 or 240, 2 wire, single phase, alternating current service. The maximum size of any heating element shall be 5500 watts. Where two heating elements are used in one tank, each element shall be controlled by an individual thermostat with interlock to prevent simultaneous operation unless the sum of the two elements is less than 5500 watts.

It is Customer's obligation to request Water Heating Credit. Company shall have right to inspect installation prior to and from time to time after application of credit to determine original and continuing eligibility.

Customers receiving water heating service under Controlled Rate or Uncontrolled Rate may request and receive Water Heating Credit provided the requirements above are met. In the case of Controlled Water Heating customers, Company will remove the submeter and thereafter apply the Water Heating Credit. Customers may increase the size of the heating elements up to 5500 watts each but must retain the interlock to prevent simultaneous operation. Alternatively, customers may remove the interlock if the sum of the ratings of the two elements does not exceed 5500 watts.

7. PAYMENTS

Bills are due and payable within ten days from date of bill.

The total monthly bill to each multiple occupancy residential building to which service is delivered and metered at one point shall be equal to the total number of dwelling units therein multiplied by the bill per dwelling unit, which bill per dwelling unit shall be calculated by applying the applicable Residence Rate to the average kilowatthour use per dwelling unit (equal to the total building use divided by the number of dwelling units, rounded to the nearest kilowatthour). Electrical use for common building services such as hall lights, elevators and laundry areas used exclusively by tenants may be metered and billed through the main building meter. Use for restaurants, arcade shops, retail stores, office space, or any other commercial venture must be separately metered and billed on the appropriate General Service or Primary Service Rate.

SYLLABUS OF UNCONTROLLED WATER HEATING AND SPACE HEATING RATE SERVICE CLASSIFICATION NO. 5 (M)

Applying to All Service Areas in Missouri

Applicable to the kilowatthour use of one or more electric water heaters and/or electric space heating equipment conforming to the special rules and regulations hereinafter set forth, provided Customer purchases electric service for general purposes under Service Classification No. 3 or 4 (General Service Rates), or Service Classification No. 7 and 8 (Optional Rates for Churches and Schools), or Service Classification No. 17 or 18 (Apartment Building Rates).

1. NET RATE BASED ON MONTHLY METER READINGS:

Rate applicable to water heating and space heating use during each of:

5 monthly summer billing periods of June through October
(See 8-D below) . . . . 3.19¢ per kwhr

7 monthly winter billing periods of November through May. . . 1.53¢ per kwhr

2. MINIMUM MONTHLY CHARGE.

$2.74 per water heater and/or space heating customer.

TABLE A15

MISSOURI ELECTRICITY RATES
(Continued)

3. FUEL ADJUSTMENT. (Rider A). Applicable to all metered kwhr.

4. TAX ADJUSTMENT.

Any license, franchise, gross receipts, occupation or similar charge or tax levied by any taxing authority on the amounts billed will be so designated and added as a separate item to bills rendered to customers under the jurisdiction of the taxing authority.

5. PAYMENTS.

Bills are due and payable within ten days from date of bill.

6. METERING.

Uncontrolled water heating and space heating service will be supplied either through a submeter to the main meter or through a separate main meter, as specified by Company. Where Customer who has an additional water heater requests and Company approves the installation of an additional submeter. Company will charge 50 cents a month for such submeter.

7. TERM OF USE.

Initial period one year, terminable thereafter on three days' notice.

8. SPECIAL RULES AND REGULATIONS.

a) Water Heating.

All water heating installations to be supplied under this rate must conform with Company's specifications, essentially as follows:

a) 30 to 55 gallon water heater equipped with one or two heating elements, suitable for 208 or 240 volt, 2 wire, single phase alternating current service. Maximum size of any heating element is 5500 watts.

b) Each heating unit to be controlled by separate thermostats and connected so that both units cannot operate at the same time if the combined wattage exceeds 5500 watts.

c) Customer receiving electric water heating service under any other applicable service classification shall be eligible to request service under this rate, provided the applicable requirements of this rate are met.

d) Customer may receive service under this rate for an installation with a storage tank of 56 gallons or more, and single or multiple heating elements of wattage ratings suitable for the particular installation which conform to good engineering practices acceptable to Company.

e) In the case of premises exclusively heated electrically but having limited requirements for hot water, such as doctors' offices, small shops and stores, etc., Company may waive the tank size and wattage limitations set forth in the preceding paragraphs. Such approvals must be in writing covering each individual application.

B) Space Heating.

In order to qualify for service under this rate, Customer's electric space heating equipment shall be a type approved by Company and shall be permanently installed on the Customer's premises.

TABLE A15

MISSOURI ELECTRICITY RATES
(Continued)

C) General.

No other electric appliance or equipment shall be attached or connected to the wiring serving the electric water heater and/or space heating equipment except: Separate electrically driven air conditioning equipment exclusively serving the electrically heated space; installations for snow melting of sidewalks or driveways or similar types of equipment for prevention of freezing; all-electric laundry equipment installed in a common laundry area used by tenants of a completely all-electric multi-family dwelling or dwellings.

D) Cumulation with Base Use.

In any summer billing period, the kwhr use normally billed on this heating rate may be cumulated with Customer's base use if the toal use equals or exceeds 25,000 kwhr, and such total use will be billed on the rate applicable to Customer's base use. Company will install a demand meter on the heating rate use, and the total billing demand on the base use rate will be the arithmetic sum of the base use and heating rate use kw demands. Customer must request such rate application in writing, and such application shall apply during the entire summer season but may by cancelled for the following summer season.

SYLLABUS OF OPTIONAL RATE FOR CHURCHES AND SCHOOLS SERVICE CLASSIFICATION NO. 7 (M)

Applying to All Service Areas in Missouri

1. NET RATE BASED ON MONTHLY METER READINGS:
   First 750 kilowatthours. . . . . @ 5.41¢ per kwhr
   All additional kilowatthours . . . . @ 3.59 per kwhr

2. MINIMUM MONTHLY CHARGE.
   $3.45 per meter.

3. FUEL ADJUSTMENT.
   (Rider A). Applicable to all metered kwhr.

4. CHARACTER OF SERVICE.

   Company will designate and supply a standard single and/or three phase alternating current secondary service voltage.

5. TAX ADJUSTMENT.

   Any license, franchise, gross receipts, occupation or similar charge or tax levied by any taxing authority on the amounts billed will be so designated and added as a separate item to bills rendered to customers under the jurisdiction of the taxing authority.

6. PAYMENTS.

   Bills are due and payable within ten days of date of bill.

7. AVAILABILITY.

   Churches, rectories, monasteries, convents, non-commercial public and parochial schools of elementary and high school rank and facilities auxillary to any of them.

TABLE A15

MISSOURI ELECTRICITY RATES
(Continued)

8. TERM OF USE.

Initial period one year, terminable therafter on three days' notice.

SYLLABUS OF PRIMARY SERVICE RATE SERVICE CLASSIFICATION NO. 9 (M)

Applying to All Service Areas in Missouri

1. NET RATE BASED ON MONTHLY METER READINGS

When Billing Demand is less than 1,000 kw:

First 100 kwhr per kw of the:		
First 200 kw.	@	4.89¢ per kwhr
Next 800 kw.	@	4.22¢ per kwhr
Next 200 kwhr per kw of billing demand.	@	1.93¢ per kwhr
Next 200 kwhr per kw of billing demand.	@	1.59¢ per kwhr
Over 500 kwhr per kw of billing demand.	@	1.31¢ per kwhr

When Billing Demand equals or exceeds 1,000 kw and is less than 10,000 kw:

First 100kwhr per kw of the:		
First 200 kw.	@	4.89¢ per kwhr
Next 800 kw.	@	4.22¢ per kwhr
Next 9000 kw.	@	3.79¢ per kwhr
Next 120 kwhr per kw of billing demand plus 80,000 kwhr per month	@	1.93¢ per kwhr
Next 200,000 kwhr per month	@	1.59¢ per kwhr
All additional kwhr up to 3,500,000 kwhr/mo.	@	1.31¢ per kwhr
Next 2,000,000 kwhr per month	@	1.20¢ per kwhr
Over 5,500,000 kwhr per month	@	1.12¢ per kwhr

When Biling Demand equals or exceeds 10,000 kw:

First 100 kwhr per kw of the:		
First 200 kw.	@	4.89¢ per kwhr
Next 800 kw.	@	4.22¢ per kwhr
Next 9,000 kw.	@	3.79¢ per kwhr
Next 5,000 kw.	@	2.98¢ per kwhr
Over 15,000 kw.	@	2.83¢ per kwhr
Next 120 kwhr per kw of billing demand plus 800,000 kwhr per month.	@	1.93¢ per kwhr
Next 200,000 kwhr per month	@	1.59¢ per kwhr
All additional kwhr up to 350 kwhr per kw of billing demand	@	1.31¢ per kwhr
Next 200 kwhr of kw of billing demand	@	1.20¢ per kwhr
Over 550 kwhr per kw of billing demand.	@	1.12¢ per kwhr

2. DEMAND

The demand is defined as the highest average load in kilowatts existing in any period of fifteen consecutive minutes.

TABLE A15

MISSOURI ELECTRICITY RATES
(Continued)

2. Demand (Con't)

The billing demand in any month will be the highest demand established during peak hours or 50% of the highest demand established during off-peak hours, whichever is higher during the month, or, for a qualifying all-electric customer, the billing demand determined in accordance with Rider C (see below), but in no event less than 150 kw.

Peak hours and Off-peak hours are defined as follows:
Peak hours - - - 8:00 A.M. to 8:00 P.M., Monday through Friday.
Off-peak hours - 8:00 P.M. (of Monday through Thursday) to 8:00 A.M. of following day, and from 8:00 P.M. Friday to 8:00 A.M. Monday).
-The entire 24 hours of the following days:

New Year's Day
Good Friday
Memorial Day
Independence Day
Labor Day
Thanksgiving Day
Thanksgiving Friday
Christmas Eve Day
Christmas Day

All times stated above apply to local effective time.

3. MINIMUM MONTHLY CHARGE

The following charge based on the highest billing demand established during the twelve months ending with the current month.

First 200 kw.	@ $2.95 per kw
Next 800 kw.	@ $2.25 per kw
Over 1,000 kw.	@ $1.90 per kw

4. FUEL RIDER

Applicable to all metered kwhr as set forth on Rider A.

5. SURCHARGE FOR DIRECT CURRENT SERVICE

For that portion of service supplied at D.C., the energy charges shall be increased by 0.40¢ per kilowatthour.

6. TAX ADJUSTMENT

Any license, franchise, or similar charge or tax levied by any Municipality which the Company is authorized to pass on to the customer will be so designated and added as a separate item to bills rendered to customers under the jurisdiction of the taxing authority.

7. PAYMENTS

Bills are due and payable within ten days from date of bill.

8. CHARACTER OF SERVICE

Company will specify and supply a standard three phase alternating current primary service voltage.

9. TERM

Contract term shall be for a period of 3 years.

TABLE A15

MISSOURI ELECTRICITY RATES
(Continued)

10. RIDER O, ALL-ELECTRIC CUSTOMERS DEMAND PROVISIONS

For any customer whose total energy requirements are supplied exclusively by electric energy purchased from Company, whose electric space heating load is 25% or more of the total connected load, the monthly billing demand will be:

1. During the 5 monthly billing periods of November through May, (a) the demand determined in accordance with the provisions of this Service Classification.
2. During the 7 monthly billing periods of November through May, (a) the billing demand determined in accordance with the provisions of this Service Classification; or (b) the highest billing demand established in any of the immediately preceding June through October biling periods, if such demand is less than (a); or (c) 50% of the maximum demand established at any time during the month, if such calculated value is more than (b); but in no event less than 150 KW.

SYLLABUS OF GENERAL SERVICE RATE SERVICE CLASSIFICATION NO. 3 (M)

Applying to All Service Areas in Missouri

1. NET RATE BASED ON MONTHLY METER READINGS:

ENERGY CHARGE	
First 40 kwhr or less	$4.02 per month
Next 960 kwhr	@ 6.36¢ per kwhr
Next 4,000 kwhr	@ 4.29¢ per kwhr
Next 20,000 kwhr	@ 3.19¢ per kwhr
From 25,000 kwhr up to 300 hours use of billing demand	@ 2.00¢ per kwhr
Next 200 hours use of billing demand	@ 1.65¢ per kwhr
Add additional use	@ 1.36¢ per kwhr

DEMAND CHARGE (Where monthly use exceeds 25,000 kwhr)	
First 150 kw included in the energy charge	None
Next 50 kw	@ $3.34 per kw
Next 800 kw	@ $2.46 per kw
Over 1,000 kw	@ $2.03 per kw

2. RATE LIMITATION.

Where monthly use exceeds 25,000 kwhr, the average rate excluding sales or similar taxes shall not exceed 3.50 cents per kwhr, except where application of the monthly minimum charge produces a higher rate.

3. MINIMUM MONTHLY CHARGE.

$4.02 per meter or the demand charge based on highest demand established during 12 months ending with current month, whichever is the higher.

4. FUEL ADJUSTMENT.

Applicable to all metered kilowatthours to compensate for changes in cost of fuel as set forth under Company's Rider "A".

5. CHARACTER OF SERVICE.

Company will specify and provide a standard single and/or three phase A.C. secondary service voltage. (D.C. is supplied in limited quantitites to existing premises in downtown St. Louis, Mo., for which a surcharge of 0.40 cents per D.C. kwhr is made.)

TABLE A15

MISOURI ELECTRICITY RATES
(Continued)

6. CUMULATION OF SERVICES.

Service taken through not more than one single phase and one three phase meter and (one D.C. meter, in downtown St. Louis, Mo.) may be cumulated for billing purposes. Any additional services supplied will be billed for separately.

7. DETERMINATION OF DEMAND.

The monthly billing demand shall be either the maximum demand measured during the month or, where elected by Customer, the billing demand determined in accordance with Rider N (see below), or for a qualifying all-electric customer, the billing demand determined in accordance with Rider O (see below), but in no event less than 150 kw.

8. TAX ADJUSTMENT.

Any license, franchise, gross receipts, occupation or similar charge or tax levied by any taxing authority on the amounts billed will be so diesignated and added as a separate item to bills rendered to customers under the jurisdiction of the taxing authority.

9. PAYMENTS.

Bills are due and payable within ten days from date of bill.

10. TERM OF USE.

Up to 25,000 kwhr per month estimated use - one year. Over 25,000 kwhr per month established use - three years. Terminable thereafter on three days' notice.

11. RIDER N, OFF-PEAK PROVISIONS.

A customer whose demand exceeds 150 kw may request this Rider, under which his monthly billing demand shall be the highest demand established during peak hours or two-thirds (2/3) of the highest demand established during off-peak hours, whichever is higher, but in neither event less than 150 kw. Off-peak hours are defined as the period from 10 P.M. of any day to 7 A.M. of the following day. Customer shall pay a surcharge of $7.00 per month as long as this Rider is in effect, which shall be for an initial period of one year, terminable thereafter on three days' notice.

12. RIDER O, ALL-ELECTRIC CUSTOMERS DEMAND PROVISIONS.

For any Customer whose total energy requirements are supplied exclusively by electric energy purchased from Company, whose electric space heating load is 25% or more of the total connected load, the monthly billing demand will be:

1. During the 5 monthly billings periods of June through October, the billing demand determined in accordance with the provisions of this Service Classification.
2. During the 7 monthly billing periods of November through May, (a) the billing demand determined in accordance with the provisions of this Service Classification; or (b) the highest billing demand established in any of the immediately preceding June through October billing periods, if such demand is less than (a); or (c) 50% of the maximum demand established at any time during the month, if such calculated value is more than (b); but in no event less than 150 kw.

APPENDIX B

LOWER MERAMEC RIVER BASIN FACILITIES PLAN

PUBLIC OPINION QUESTIONNAIRE

Workshop #1

1. Do you favor a wastewater treatment study of the Lower Meramec River Basin? Yes No

2. If "No" is circled for item one (1) above, do you feel that: (Please circle appropriate choice according to the following definitions).

A - Agree very strongly C - Agree slightly

B - Agree strongly D - Not applicable to me

(a) There are no wastewater treatment problems and, therefore, no need for a wastewater treatment plan for the Lower Meramec River Basin. A B C D

(b) Adverse environmental impact from implementing a wastewater plan is worse than having no areawide plan. A B C D

(c) Wastewater treatment should be the responsibility of an individual or community and no areawide plan should be imposed. A B C D

(d) Implementing an areawide treatment system will significantly harm local industry and citizenry. A B C D

(e) Other: Please explain.

____

____

____

3. If "Yes" is checked for Item one (1), do you feel that:

(a) There are environmentally sensitive issues in the Lower Meramec River Basin. Yes No

4. If "No" is circled for Item three (3), this is the end of the questionnaire. Thank you for helping us. Please send questionnaire to address indicated in Item Seven (7), or return at the end of this meeting.

5. If "Yes" is circled for Item three (3), do you feel that the environmentally sensitive issues in the Lower Meramec River Basin are: (Please circle either "Yes" or "No" for each lettered item).

(a) Air Pollution	Yes	No
(b) Surface Water Quality (streams & lakes)	Yes	No
(c) Archeology (historical sites)	Yes	No
(d) Ground water quality (well water)	Yes	No
(e) Population growth	Yes	No
(f) Rare and endangered plants or animals	Yes	No
(g) Recreation	Yes	No
(h) Operation of industry in the area	Yes	No
(i) Transportation	Yes	No

(j) Other: Please Explain.

____

____

____

6. For each "Yes" answer circled in Item five (5), please explain further below.

7. This completes the public opinion questionnaire. Please mail to:

Clean Water Memorandum
P.O. Box 20611
Southwest Station
St. Louis, MO 63169

Please take with you an additional public opinion questionnaire for those persons who would be interested in this project and expressing their views.

In order for the views expressed in this questionnaire to be considered, it is not a requirement that it be signed prior to submitting. However, if you would like to be identified with your views, please sign the questionnaire.

Thank you for helping us.

Signature (not required)

SUMMARY SHEET ON FACILITIES PLAN FOR THE LOWER MERAMEC RIVER BASIN

(Lower Meramec River Basin map attached)

Background on Existing Wastewater Treatment

Wastewater treatment in the Lower Meramec River Basin consists of municipal systems, private sewer companies and a multitude of installations using individual systems.

Sewage works in the study area consist of sewage treatment plants, lagoons, pump stations, and collection systems of various sizes.

Of the three wastewater treatment levels, primary (lowest treatment level), secondary (medium treatment level) and tertiary (highest treatment level), almost all industrial and municipal waste treatment is at the secondary level. Individual treatment facilities vary from primary (septic tank systems) to secondary treatment (mechanical plant or lagoon).

Planning to Meet Future Wastewater Treatment Requirements

The Federal Water Pollution Control Act Amendment of 1972 (Public Law 92-500) has established future wastewater treatment goals. Essentially, this law establishes limits on the amount of a pollutant that may be discharged into a body of water.

The first goal of this law is to achieve by July, 1983, water clean enough for swimming and other recreational uses, and for the protection and propagation of aquatic wildlife.

The second goal is to have no discharge of pollutants into the nation's water by 1985.

Industries must meet limitations that are based on the "best practicable" control technology by July, 1977, and the "best available" technology by 1983. Municipalities, on the other hand, must provide a minimum of secondary treatment by July, 1977, and meet limitations that are based on the "best practicable" treatment by July, 1983.

The Federal Water Pollution Control Act Amendment consists of several sections that, together, provide guidelines and procedures for achieving the national water quality goals. Section 201 of this act defines and describes one step, the facilities plan. Our project is to prepare a facilities plan (or 201 study plan) for the Lower Meramec River Basin.

The facilities plan study culminates with a report that contains a technical, economic and environmental assessment of alternative plans to meet the requirements of the Federal Water Pollution Control Act Amendment.

The Project--Facilities Plan (201 Study) for the Lower Meramec River Basin

What is a Facilities Plan?

A facilities plan covers the planning and preliminary design portions of plans and studies related to construction of publicly owned waste treatment works. Facilities plans, through systematic evaluation of alternatives, assure development of cost-effective and environmentally sound municipal waste treatment systems.

Facilities plans are limited, essentially, to abatement of pollution from municipal point sources and those industries served or to be served by municipal waste treatment systems.

Environmental Requirement of a Facilities Plan

The National Environmental Policy Act of 1969 (NEPA) requires an environmental impact statement (EIS) for all major federal actions significantly affecting the quality of the human environment. It has been determined that the Lower Meramec River Basin facilities plan constitutes a significant major action and, therefore, requires the preparation of an EIS.

What is an Environmental Impact Statement (EIS)?

An EIS consists of a detailed study describing the existing environment within the study area and the potential positive and negative impacts that may occur to the environment should the selected project or viable alternatives to the project be implemented.

The environment and potential impacts to it are described by three primary environmental factors:

Biology (plant and animals)
Phyical Resources (e.g., geology, air science, hydrology, etc.)
Socio Economics (population growth and distribution, land use, recreation, etc.)

What is the Purpose of this Workshop?

One of the main purposes of this workshop is to inform you of the facilities plan study and its purposes. More importantly, however, the purpose of this workshop and others to come is to get your views and opinions on what you want done about wastewater treatment in the Lower Meramec River Basin.

Equally important is particular knowledge that you have about sensitive environmental issues existing in your area that will help us prepare an EIS that addresses all relevent issues.

This, and other workshops to come, is an opportunity to have your views concerning wastewater treatment in the basin known so that they can be considered in wastewater treatment planning in the future.

To help us identify your views on sensitive environmental issues, a public opinion questionnaire has been prepared. Please take the time to complete this questionnaire and mail it to:

Clean Water Memorandum
Post Office Box 20611
Southwest Station
St. Louis, MO 63139

PUBLIC INPUT QUESTIONNAIRE
LOWER MERAMEC 201 FACILITIES PLAN
ENVIRONMENTAL CONSIDERATIONS

1. Name (preferred, but optional)____________________________

2. Representing: Self_______ (or) Name of Organization______

____

3. Address____

4. Special Interests in 201 Project____________________________

____

5. How did you hear of meeting? Newspaper___________________

Clean Water Memo__________ Radio__________ Friend_________

Other____

6. The Facilities Planning Program for the Lower Meramec Basin can be implemented in two ways. The first program, involving a Regional Concept, calls for building a single large treatment plant near the mouth of the Meramec River. A major sewer line would collect the sewage from each subarea and deliver it to the regional plant for secondary treatment; the treated water would be discharged into the Mississippi River. The second program, involving a Subregional Concept, calls for locating about eight small treatment plants throughout the Meramec Valley. The treated water would be discharged into the Meramec River at each plant location. Because of state requirements, water discharged into the Meramec River must receive tertiary (advanced) treatment. A third alternative would be to do nothing. The environmental impacts of no action would be continued degradation of water quality and, quite likely, reduced growth within the proposed service area.

QUESTIONS

a) Based upon the environmental and economic information provided at this public meeting, which plan would you prefer for the basin?

1) Regional (one plant)____________

2) Subregional (multiple plants)___________

3) No Action__________

b) Why?____

____

____

c) What environmental or economic considerations should be expanded or added at this planning stage of this project?

____

____

____

____

7. One of the reasons wastewater management planning has and is being conducted in the Lower Meramec River Basin was the threat of a construction ban in the early 1970's. Water pollution in the tributary creeks, and the potential for groundwater contamination was increasing as the population in the area grew and residential areas expanded. If wastewater treatment facilities are not constructed, it is very likely that limitations will be placed on the economic and population growth in the basin. If treatment facilities are provided, projected growth trends for the area (30 percent growth by the year 2000) should be realized. The environmental effects of population growth can be summarized as:

- Continued growth of currently vacant land for residential, commercial, transportation and industrial uses
- Increased noise and air pollution
- Increased economic growth, accompanied by a broader tax base and increased employment

PUBLIC INPUT QUESTIONNAIRE
Page Three

QUESTIONS

a) How do you feel about continued growth in the Lower Meramec Basin?

Favor all growth______________

Favor growth with good planning____________

Favor maintaining present level of population and economic growth____________________

Undecided______________

b) What factor(s) related to growth and development do you feel merit additional, special consideration in planning for this project?__________________________

____

____

____

8. The Bureau of Outdoor Recreation of the U. S. Department of the Interior, the Missouri Department of Natural Resources, and St. Louis County have been actively developing and implementing a program to increase recreational facilities and other open space areas along the Lower Meramec River. The removal of pollution sources from the river is essential in realizing the full recreation potential for this area.

QUESTIONS

a) Have you ever used the Meramec River (from just west of Valley Park to the mouth) for recreation?

Yes________

No_________

b) If yes, for what activities?

Fishing________ Swimming___________

Canoeing________ Other_________________________

c) Would you like to see the water quality in the Meramec improved so that water contact activities (i.e., swimming) could be safely permitted?

Yes________

No_________

d) Would you use the Lower Meramec River more frequently if there were better access and cleaner water?

Yes________

No_________

e) Do you feel the time and money needed to remove the municipal wastewater discharges from the Meramec River and clean the water is justifiable?

Yes________

No_________

9. The State of Missouri's Clean Water Commission (CWC) requires a higher level of treatment for effluents discharged to the Meramec River than it does for effluents discharged to the Mississippi River. The CWC also requires that no effluents be discharged to Grand Glaize and Fishpot Creeks, in the Lower Meramec River Basin. Likewise, the guidelines of the Missouri Division of Health require that wastewater only be discharged downstream from potable water intake locations. The potable water intake locations of the Kirkwood Municipal System and the St. Louis County Water Company are on the Meramec River, downstream from Kiefer, Grand Glaize, Fishpot and Williams Creeks. Therefore, any municipal wastewater discharged into these creeks would flow downstream to the potable water intake locations of the two water systems. These restrictions on wastewater discharge are designed to clean the Meramec River thus enhancing its value as a recreational stream (e.g., for fishing, canoeing, camping in parks along river) and permitting future withdrawal of drinking water.

QUESTIONS

a) Based on this background information, which of the alternative plans do you feel would be in the best interest of the public?

_____No Action. Continue present discharges at numerous points in the Lower Meramec Basin. Continue to add pollutants to the creeks and river. Do not incur the economic burden of a new treatment system.

_____Subregional Plants. Individual tertiary (i.e., high level) treatment plants within the Basin. This would eliminate discharges to the tributary creeks. However, approximately eight subregional plants located at the mouths of the major creeks would discharge into the Meramec River. Several of these plants would discharge upstream from public water intakes. Water in the Meramec River would approach the quality necessary for recreation and potable uses.

_____Regional Plant. Almost all discharges into the Meramec and its tributary creeks would be eliminated. Wastewater from the basin would be collected and conveyed to a single, large plant near the mouth of the Meramec River. Water in the Meramec River would approach the quality necessary for recreation and potable uses.

Please make any comments or suggestions relative to this project which were not covered elsewhere in this questionnaire:____

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**RYCKMAN, EDGERLEY, TOMLINSON
AND ASSOCIATES**
12161 Lackland Road
St. Louis, Missouri 63141
(314) 434-6960

a division of Envirodyne Engineers

June 9, 1976
RETA-2806

Dear

Ryckman/Edgerley/Tomlinson & Associates, Inc., (RETA), is under contract to Metropolitan St. Louis Sewer District to prepare an Environmental Impact Statement (EIS) on a unified program of Sanitary Sewage Collection and Treatment in the Lower Meramec River Basin (study area map attached). The EIS is being prepared concurrently with a Facilities Plan in pursuant to Section 201, P.L. 92-500 of the Federal Water Pollution Control Act Amendments of 1972.

In order to assure addressing in the EIS as many relevant environmental issues as possible, RETA is soliciting by this letter, general comments and/or statements of concern regrading any aspect of the project or project area that you feel merits special attention.

Thank you in advance for your attention to this letter, and I would welcome any comments or suggestions that you may have.

Very truly yours,

Richard E. Tucker, Ph.D.
Project Manager

RET/sdv
Enclosure

APPENDIX C

APPENDIX C

THE METROPOLITAN ST. LOUIS SEWER DISTRICT
COMPREHENSIVE SOLIDS MANAGEMENT PLAN

U.S. EPA Project No. C291124-01
Havens and Emerson, Inc. - Consulting Engineers

SCOPE OF WORK

The CONSULTANT shall perform all professional engineering and planning services required to prepare a comprehensive Solids Management Facilities Plan consistent with EPA Section 201 guidelines for all of the ash, sludge, grit, and screenings generated by the wastewater treatment facilities within the DISTRICT, described in detail as follows:

1. Plan of Study - Grant Application

a) Prepare Plan of Study including cost estimates and time schedule; and obtain approvals by DISTRICT, MDNR, EPA.
b) Assist DISTRICT in preparing and submitting Step 1 grant application for funding.

2. Data Acquisition

a) Inventory all solids sources within DISTRICT.
b) Determine regionalization pattern for study.
c) Establish population and service areas, each plant.
d) Project population and solids quantity, each plant.
e) Determine applicable regulations for solids disposal on land.
f) Lab testing of ash and sludges for COD and metals.
g) Survey existing commercial and public landfills.
h) Consult with state and local health and regulatory agencies regarding applicable landfill and storage requirements.

3. Ash Disposal (For Bissell and Lemay Plants)

a) Determine on-site storage capability for dry or wet ash at Bissell and Lemay.
b) Determine ash characteristics which may have environmental effects.
c) Determine average and peak production rates; present and future.
d) Locate possible ultimate disposal sites within 50 mile radius.
e) Evaulate alternate ash sites; transport methods, routes, useful life and required site work.
f) Make cost-effective comparison of alternate sites, including site preparation, transport cost, site closure costs.

g) Determine environmental effects on alternate sites including runoff and leachate control, water quality impacts, air impacts and resource commitments.
h) Prepare cultural resource surveys of alternate disposal sites, including possible archaeological, historic and environmentally sensitive resources.
i) Examine possibilities for commercial use of ash and possible markets for the material.
j) Study administrative and institutional aspects of alternatives; DISTRICT or other ownership and control.
k) Compare alternatives and select preferred alternatives.

4. Sludge and Other Solids (For all DISTRICT service area outside Bissell and Lemay Sub-Districts)

a) Determine quantities and characteristics of residual solids; project future quantities; determine average and peak rates.
b) Study applicability of sludge processing alternatives.
c) Develop alternatives for ultimate disposal of solids as required by EPA guidelines. Alternatives shall accommodate a range of in-plant solids processing possibilities.
d) Determine feasibility of regional solids processing plant to serve outlying treatment plants.
e) Prepare cost-effective analyses of solids management alternatives, including capital cost, operation and maintenance, make present worth analysis.
f) Determine environmental impacts of alternatives on land, air and water environments, including resource commitments, cultural resources, archaeological and historic sites, flood plains, etc.
g) Evaluate alternatives on cost-effectiveness and environmental impacts; compare and select preferred alternatives.

5. Development of Project Plan

a) Using data from parts 3-5 above, assist DISTRICT in conducting preliminary and final public hearings; summarize and incorporate public input.
b) Develop an overall project plan for solids management for all DISTRICT, including ash, sludge and other solids.
c) Prepare an environmental assessment statement for the project plan, suitable for public comment and hearings.
d) Prepare draft report of recommended project plan; submit for review by DISTRICT, State of Missouri and EPA.
e) Incorporate review comments and modifications, prepare and submit final project plan report; assist DISTRICT in obtaining approvals.

6. General Performance

a) During progress of the work, confer with DISTRICT, MDNR and EPA; maintain close liaison with their project officers.
b) Prepare and submit monthly progress reports.
c) Assist DISTRICT in preparation for and conduct of public participation and hearings.
d) Coordinate with other planning in progress by 201 contractors.
e) Coordinate with 208 agency, and develop plan consistent with the 208 areawide plan.